MARINE AND COASTAL ECOSYSTEM SERVICES

A report on ecosystem services in the Pacific North Coast Integrated Management Area (Pncima) on the British Columbia coast

David Suzuki Foundation
SOLUTIONS ARE IN OUR NATURE

Living Oceans Society
Healthy Oceans. Healthy Communities.

Sierra Club BC

Produced by the David Suzuki Foundation in collaboration with the Living Oceans Society and the Sierra Club of B.C.

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For more information on Pncima and to find our how you can help conserve ecosystem services, visit the websites of the organizations listed above or go to:

www.pncimamatters.ca or www.healthyoceans.ca

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Executive Summary

With the launch of *Canada's Ocean Strategy* in 2002, the Canadian government formally recognized the need to take action to help maintain the health of Canada's ocean environments. The strategy identified several Large Ocean Management Areas (LOMAs) that would be priority areas for developing integrated management plans aimed at preserving healthy, vibrant ecosystems and human communities in these regions. One of these LOMAs is an area off Canada's North Pacific coast called the Pacific North Coast Integrated Management Area (Pncima).

By definition, integrated management plans require a significant understanding of the values, processes, and existing socio-economic elements in the area under consideration. When possible, scientific information should be used to inform decision-making. A growing and necessary body of information to consider in these types of management planning processes is commonly known as natural capital and ecosystem services.

The purpose of this report is to present known information about ecosystem services and to identify gaps in information that should be filled to support the implementation of an integrated ocean management plan in the Pncima. The maintenance of ecosystem goods and services is considered in this application as a foundation for sustainable economic and social development in the marine environment.

Utilizing ecosystem services concepts and elements in the marine planning field requires a clear accounting of the range of ecosystem services provided by the coastal and marine environments.

The ocean may not be a top-of-mind issue for most people, but it has an impact on everyone's well-being. The seas provide a significant amount of the food we eat and supply approximately 50 per cent of the oxygen in the air we breathe. The Earth is habitable for humans largely because of the ocean's role in regulating our climate. In Pncima, marine and coastal ecosystems also play a role in accommodating a unique society and support the local economy in many ways:

- Fisheries provide up to one-quarter of regional employment income, amounting to more than $2.6 million annually on the Central Coast alone.

- Natural structures mitigate the effects of extreme weather events, potentially saving thousands of lives and hundreds of thousands of dollars.

- As a popular destination for nature-based recreation, the Pncima region attracts more than $60 million in tourism revenues each year.

- Thanks to the pristine nature of the marine environment, any number of discoveries – from learning how diatoms sequester carbon to the extraction of anti-cancer drugs from our marine resources – could distinguish the region as a centre for scientific innovation and enterprise.

Despite the abundance of benefits the ocean provides, human beings have mapped more of the moon than the sea floor. Knowledge gaps exist with respect to our understanding of marine biodiversity, ecosystem functioning, and the effects of global warming and climate change.

If decisions on marine use, management, and conservation are to be effective, they must be informed by a good understanding of ecosystem services. To realize this, more priority must be placed on research, mapping, and valuation of these services, the identification of ecosystem indicators and thresholds to measure management activities, and the interaction between ecosystem services and the various scales across which they operate.

In addition to developing a comprehensive base of evidence to support the protection of key ecosystem services, more research will help reveal both what we do and don't know about the Pncima region, and how to balance this new knowledge with existing social values.

This report offers suggestions for conservation objectives that should be considered in protecting ecosystem services – particularly those of major significance to the Pncima region. These objectives hinge largely on three separate commitments from the federal government to pursue further research and monitoring, and to design appropriate finance, policy, and governance structures for vulnerable marine resources. More specifically, the commitments and associated conservation objectives entail the following:

- <u>A Commitment to Further Research</u>: Lack of knowledge with respect to ecosystem services is due both to the lack of relevant data and to the multivariate complexity of the concept. Both forms of research should be pursued in Pncima.

- <u>A Commitment to Monitoring</u>: In order for the above research to provide lasting benefits, there must be a clear commitment to monitoring in Pncima, and the question of what to monitor is as important as the commitment to monitor.

- <u>A Commitment to Governance Structures</u>: The former two commitments rest on a commitment to the design of appropriate finance, policy, and governance structures. Ecosystem services need to become a factor in policy decision-making, which requires an appropriate framework and governance structure.

In light of the federal government's commitment to move forward with a marine planning process in the Pncima, there is a need to define and secure agreement among stakeholders, government, and First Nations in the region regarding conservation objectives for this process. As a contribution to the discussion about conservation objectives for the Pncima, the following objectives are recommended:

- Protect ecologically viable proportions of each habitat type from the pressures of human activity to maintain ecosystem processes.
- Establish management systems that maintain the biological integrity, resiliency, and productivity of the marine and coastal ecosystems at a range of spatial scales.
- Rehabilitate under-represented and/or rare habitat types to a state of historic functional and ecological integrity.
- Establish spatial zoning for specific industrial practices to minimize the risk and probability of human-induced disasters to important ecosystem processes and biological communities.
- Maintain primary productivity within the bounds of natural variation.
- Establish strategies to reduce the risk of negative environmental impacts from industrial activity in or near the marine environment.
- Sustain ecological and evolutionary processes within an accepted range of variability.

As a society that is highly interdependent with its surrounding environments and ecosystems, we need a deeper understanding of how our oceans function and what they offer us if we hope to maintain the ocean's essential services in the long term. We hope that the information in this report will assist those making decisions and directing research that will inform ocean conservation and management decision in the Pncima.

Abbreviations

AAAS	American Association for the Advancement of Science
ALR	Agricultural Land Reserve
B.C.	British Columbia
BCMCA	British Columbia Marine Conservation Analysis
CGRCS	Canadian Groundfish Research and Conservation Society
DFO	Department of Fisheries and Oceans (Fisheries and Oceans Canada)
EBM	Ecosystem-Based Management
EBSA	Ecologically and Biologically Significant Area
FAO	World Food and Agriculture Organization
GESAMP	Group of Experts on Scientific Aspects of Marine Environmental Protection
IFRC	International Federation of Red Cross and Red Crescent Societies
IPP	Independent Power Producer
IUCN	The World Conservation Union (International Union for Conservation of Nature)
LOMA	Large Ocean Management Areas
MEA	Millennium Ecosystem Assessment
NASA	National Aeronautics and Space Administration
NRTEE	National Round Table on the Environment and the Economy
OCC	Ocean Coordinating Committee
OFDA/CRED	Office of U.S. Foreign Disaster Assistance/ Centre for Research on the Epidemiology of Disasters
PNCIMA	Pacific North Coast Integrated Management Area
SEA	Strategic Environmental Assessment
TEK	Traditional Ecological Knowledge
UNEP	United Nations Environmental Programme
WRI	World Research Institute
WTO	World Travel Organization

Glossary

Biodiversity	The variety of life forms, as well as the habitat and natural processes that support them, within a particular ecosystem.
Ecosystem	Encompasses the living (plants, animals, micro-organisms) and non-living (water, air) elements that interact in a given area.
Ecosystem Services	The benefits ecosystems and ecosystem processes provide to society, such as healthy seafood, clean water, and protection from natural disasters and storms.
Ecosystem-based Management	An adaptive approach to resource management that seeks to address the entire ecosystem – including both human and environmental impacts and influences – instead of just one aspect, issue, or resource. EBM seeks to maintain those spatial and temporal characteristics of ecosystems such that component species and ecological processes can be sustained and human well-being supported and improved.
Ecotourism	Tourism that is based on environmentally responsible travel and visitation to relatively undisturbed natural areas, in order to enjoy and appreciate nature (and any accompanying cultural features – both past and present) in a way that promotes conservation, has low negative visitor impact, and provides for beneficially active socio-economic involvement of local populations.
Eutrophication	When a body of water becomes anoxic (low oxygen) due to an overload of nutrients.
Indirect and Induced Impacts	Indirect and inducted impacts are the changes in economic activity from subsequent rounds of re-spending of wage income. Indirect effects are the changes in sales, income, or employment within the region in industries that supply supporting goods and services to ocean-based industries. Induced impacts are the increased sales within a region from household spending of the income earned from ocean-based industries.

Integrated Management
An ongoing and collaborative planning process, involving stakeholders and regulators, that seeks to reach agreement on the best mix of conservation, sustainable use, and economic development of marine areas for the benefit of all Canadians.

Precautionary Approach
The absence of full scientific certainty shall not be used as a reason to postpone decisions where there is a risk of serious or irreversible harm.

Sustainable Development
Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

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Section 1: Introduction

Problem Definition

For millions of years, humankind had little impact on the character of marine ecosystems. But exponential growth in the world's population – from one billion people in 1800 to over six billion in 2008 – and rapid advances in technology are now leaving a discernible imprint. The prognosis for ocean health is not good.

At this moment, populations of many species of marine life are rapidly declining due to overexploitation, habitat destruction, proliferation of invasive species, pollution, and climate change (MEA 2005; UNEP 2006). Recent studies published in academic journals suggest that more than 90 per cent of large predatory fish have gone extinct since pre-industrial times (Meyers and Worm, 2003), that coral reef ecosystems will disappear within a few decades without protection from human exploitation (Pandolfi et al., 2003), and that 60 per cent of ecosystem services are currently being degraded or used unsustainably (Tallis and Kareiva, 2005). In short, the scientific community is reporting that the marine environment is changing in response to causes that are largely anthropogenic. This report, however, doesn't seek to add to the well-established evidence about how we are impacting the oceans. Instead, it's about the range of benefits they provide to society and what we stand to lose if we don't act now to protect ecosystem services.

The dangers of human-induced damage to oceans are beginning to enter public consciousness, as society is increasingly aware of the phenomenon of "dead zones", the existence of invasive species, and the fact that that certain marine species have been exploited to the brink of extinction. The *interdependence* of mankind and ocean ecosystems, however, is often not as well understood or appreciated. There are many reasons for this, but perhaps the most compelling is the current state of knowledge about marine ecosystems on the part of both scientists and the general public.

Relative to terrestrial environments, very little is known about marine environments and their functional processes. A well-known cliché in the scientific community suggests that we know more about the moon than the ocean's depths. Large areas of the ocean remain unexplored and uncharted, and while the story of how this vast system functions and impacts mankind *is* emerging, it is far from complete. As of 2005, it was estimated that 90 per cent of the sea floor remained to be mapped in detail (Handwerk, 2005). This situation makes it rather difficult to fully appreciate the range of services the environment provides. A United Nations synthesis report on the marine and coastal findings of the Millennium Ecosystem Assessment (MEA) states:

> *"There are major gaps in our knowledge of marine and coastal ecosystems and in methodology to assess and manage them… The inadequacy of data on the extent and status of many marine*

and coastal ecosystems makes it difficult to estimate the extent of past change and future trends." (UNEP, 2005. p 7)

General public perception reflects knowledge gaps with respect to marine environments as well, including unrealistic perceptions of inexhaustible resources, the state of ocean health, and the interconnected nature of human and ocean health. In addition, key people who determine the direction of coastal and ocean policies are generally unknown and unaccountable for their decisions (AAAS, 2004; Craig, 2007). Most people are generally either unaware of the state of the oceans and how it impacts them, or if aware, perceive themselves to be powerless in influencing marine policies. A study carried out in November 2003 by the American Association for the Advancement of Science (AAAS) found that although eight out of 10 respondents agreed that human-made stressors are endangering coastal regions and the open ocean, only three out of 10 respondents felt their personal actions had significant influence on ocean health.

In this report, we articulate the importance of the marine ecosystem to humankind by examining how it impacts mankind across economic, physical, and social spheres. The report also identifies the leading questions with respect to ecosystem services, including issues currently under active investigation.

Although marine ecosystems face many problems and issues, this report addresses those specific problems associated with the state of knowledge of marine ecosystems and ecosystem services. It examines what we know as well as what we don't know, and how to balance this relatively newfound knowledge about ecosystem services with existing social values.

Policy Response for Ocean Health

Governments around the world are recognizing and responding to the declining state of the oceans. Numerous symposiums have been hosted to share knowledge and to develop international agreements aimed at improving ocean conditions. In 1992, the United Nations Conference on Environment and Development ("the Earth Summit") drafted Agenda 21, a program of action for global sustainable development by the 21st century. Chapter 17 of Agenda 21 addresses the protection of oceans through the rational and long-term sustainable use of their living resources (UN-Oceans 2008). In the period since this commitment, nations have deferred on the task of how to fulfill such promises. This difficulty has not escaped Canada.

The Canadian government created comprehensive oceans management legislation in 1997 with the introduction of the *Oceans Act*. The guiding theory underlying this legislation is ecosystem-based management (EBM), an adaptive approach to managing human activities that seeks to ensure the coexistence of healthy, fully functioning ecosystems and human communities. This theory is reflected in the principles of the act:

- sustainable development – "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs.*" (United Nations, 1987)
- integrated management – "*an ongoing and collaborative planning process that brings together interested stakeholders and regulators to reach agreement on the best mix of conservation, sustainable use and economic development of marine areas for the benefit of all Canadians.*" (DFO, 2008)
- the precautionary approach – "*the absence of full scientific certainty shall not be used as a reason to postpone decisions where there is a risk of serious or irreversible harm.*" (Environment Canada, 2008)

The *Oceans Act* was expanded in 2002 under Canada's *Oceans Strategy,* and again in 2004 under the *Oceans Action Plan.* These documents contain long-awaited prescriptions on how to implement the commitments and principles laid out in the *Oceans Act* – including the designation of five large ocean-management areas (LOMAs) for planning purposes. The LOMAs represent a range of ocean habitats across Canada, with one in the Pacific region (Pacific North Coast), one in the Central and Arctic region (Beaufort Sea), and three in the Atlantic region (Gulf of St. Lawrence, Eastern Scotian Shelf, and Placentia Bay/Grand Banks).

The implementation of integrated management plans is proceeding at varying paces across the regions. This process involves the organization and collaboration of all interested parties in determining how the relevant area will incorporate environmental and development interests. This report focuses on the Pacific North Coast Integrated Management Area (Pncima, pronounced pen-SEE-ma), which is the Pacific region LOMA. More specifically, it aims to inform the reader of the many benefits provided by marine environments, with specific emphasis on Pncima, to ensure that those engaged in the planning process are able to articulate and prioritize key conservation needs and to develop management and conservation recommendations that serve to protect these benefits.

Ecosystem Services & Their Valuation

The process of balancing marine ecosystem benefits with societal developmental benefits presupposes that we have a grasp of the range of values offered by the marine environment. This couldn't be further from the truth. While the value of development is relatively straightforward and routinely measured in economic terms, the same cannot be said for ecosystem benefits or services. Not only are we uncertain of the extent of services provided by the ocean, we are far from consensus on *how* to value these services.

Ecosystems, or the community of plants and animals that interact with one another and their physical environment, provide mankind with services that are wide-ranging and diverse, from providing food to regulating waste and nutrient supply to supporting cultural and recreational activities. The collective benefits provided by the resources and processes supplied by natural environments are known as ecosystem services. These services are often taken for granted, partly due to a lack of knowledge regarding what they are and what they're worth.

Historically, markets have captured the value of certain essential goods provided by the natural environment but have failed to capture others, most notably fundamental life-supporting services. For example, food, fibre, and fuel have been valued in markets for centuries, while climate regulation, carbon sequestration, and oxygen production have failed to garner market signals that would alert society of changes in their supply or deterioration of the underlying ecosystems that support them. All too often, their value is only appreciated upon their degradation or scarcity.

Our failure to appreciate the vital role of natural ecosystems is understandable. By the time humanity appeared on the Earth, ecosystems had been operating for hundreds of millions of years, producing services that are so fundamental to life and occurring on such a large scale that it was hard to envision how human activity could possibly disrupt them (Daily et al., 1997). This is no longer accurate. Science is revealing that as natural environments are altered for human purposes, feedback is experienced by humankind. In other words, we cannot continue to deplete species, destroy habitats, and pollute environments without ultimately impacting our own well-being. This implies that decision-makers should not continue to assign an implicit cost of zero to ecosystem services in the face of potential development. How to value such services has become an active area of study. Ecologists and economists are now working together to assign values to ecosystem services to ensure that their importance is not overlooked in the face of human development. (See Appendix A for a summary of valuation methods.)

Given that some of the functions of marine ecosystems have significant value to humans, some economists have attempted to aggregate their worth in dollars. For instance, Costanza et al. (1997) estimated the value of marine ecosystems to be over $20 trillion, with the majority of this figure (60 per cent) coming from coastal ecosystems. More recently, Martinez et al. (2007) concluded that the value of coastal ecosystem services added up to $25 billion per year. It is important to keep in mind, however, that many functions of the marine ecosystem are essential to supporting the ocean system in its entirety and play a part in supporting all life, regardless of any direct monetary value to the human species (McKay et al., 1991). In this respect, the ocean is truly priceless.

Recognizing that economic valuation alone could not adequately capture the worth of ecosystem services, the authors of the Millennium Ecosystem Assessment (MEA) charted a new pathway to evaluate the importance of the Earth's human support systems. Their audit, which involved hundreds of experts (approximately 1,360) and spanned four years, sought to directly connect ecosystem changes with human well-being. In doing so, it forged links between the health of biotic systems and their benefits to society. These links are discussed in economic, health, and social terms, allowing a more holistic assessment than one that focuses exclusively on market value. Many of the links are obvious while many others are not often appreciated, nor are they all quantified. The following report follows the methodology of the MEA in that the value of ecosystems is assessed from a range of viewpoints (i.e., health, social, and economic).

While the MEA framework expands the scope of ecosystem valuation, it would be irresponsible to present this valuation as representative of the full range of the benefits ecosystems provide to society. Time constraints and methodological issues necessitate that, at minimum, option use values, bequest values, and intrinsic values are not explicitly addressed in this study. Nonetheless, the following values are embedded in every service discussed in this study:

- <u>Option use values</u>: Option use refers to the potential future use(s) of a natural environment. A healthy marine ecosystem contains many goods and services not yet discovered, such as new species of edible fish or medicinal products.
- <u>Bequest values</u>: Bequest value refers to the value of preserving a natural environment for the use of future generations.
- <u>Intrinsic values</u>: Intrinsic value implies that natural environments deserve protection for their own sake, as an end, and not just because of what they provide for humans.

Lastly, given the many connections and linkages among ecosystem services, it is highly likely that the value of the whole, intact ecosystem is greater than the sum of its parts.

Study Objectives & Outline

The overarching purpose of this ecosystem services analysis is to support and promote the implementation of integrated oceans management in the Pacific North Coast Integrated Management Area (Pncima). More specifically, it strives to support the formal launch of a science-based, participatory planning process by the federal government. In doing so, the project examines the concept of ecosystem goods and services as a base for sustainable economic and social development needs. This requires a clear accounting of the range of ecosystem services provided by coastal and marine environments, in the Pncima region specifically. As well as developing a comprehensive evidence base to support the protection of key services, communicating where knowledge gaps exist will identify further research needs.

The objectives of this report are threefold:

(i) Inform stakeholders of the scope of ecosystem goods and services provided by coastal and marine ecosystems, with particular attention paid to Pcnima;

(ii) Assess the current state of knowledge surrounding ecosystem goods and services in Pncima. This includes identifying gaps in information and recommending where additional research funding should be allocated to fill these gaps; and

(iii) Provide recommendations based upon the results of objectives (i) and (ii) for the Pncima planning process. These recommendations will address both future research and conservation objectives.

The first objective provides the basis of the report by examining what subset of services exist in the marine environment along the Central and North Pacific coasts, and why they are important from both an ecological and a socio-economic perspective. This is accomplished in a stepwise manner. Section 2 presents a conventional economic valuation of the ocean environment in Pncima. That is, this section measures the market value of the ocean environment, factoring in all relevant sectors that depend on the ocean as a medium for transport and operations, as well as a source of extractable resources. This is to be compared with Section 3, which addresses both market and non-market values of the ocean environment through the framework of ecosystem services as classified by the Millennium Ecosystem Assessment. This will exhibit an increase in the scope of services, as well as an increase in valuation viewpoints – including the value of oceans from social and health perspectives, as well as an economic perspective. Both sections are based upon a comprehensive literature review and direct interviews with various research groups and organizations.

The latter objectives evaluate the state of knowledge surrounding ecosystem services in the Pncima, and identify key research needs that require attention in the near term, as well as more ambiguous knowledge gaps where the precautionary principle should be evoked. These objectives were met through a combination of literature review and expert interviews. Ongoing research specifically related to an ecosystem service is addressed in Section 3 of this report, whereas Section 4 identifies key research gaps.

The conclusions of this report will feed into a communications strategy designed to build understanding among all stakeholders of the rationale for improved management of the Pncima region. Additionally, the report will act as a technical document that highlights future research needs and recommended next steps in the planning process.

Pncima

The Pncima region covers 88,000 square kilometres, from the Canada-Alaska border in the north to the northern tip of Vancouver Island in the south, including the island of

Haida Gwaii, and from Brooks Peninsula on the west side of Vancouver island to Bute Inlet on the east side (see Figure 1). Located in a transition zone, north of where the eastward-flowing subarctic current diverges into a north-flowing and downwelling Alaska Coastal Current and a southward-flowing and upwelling California Current, Pncima is unlike other areas of the North American west coast (Lucas et al., 2007). Steep mountains, fjords, islands, estuaries, rivers, and inlets dissect and carve the entire coast. The waters here are home to a great diversity of ecosystems, habitats, and marine organisms. Glass sponge reefs once thought extinct, vast forests of kelp and underwater mountain ranges, 27 different types of whales, and over 400 species of fish all reside in or migrate through Pncima.

Approximately 34,500 people live in 25 communities throughout Pncima. The residents have historically relied heavily on the resources provided by the ocean and coastal environment. Today, signs of stress are emerging from proposed and existing industrial activities. If environmental and economic health is desired in the long term, an integrated, holistic approach to marine management and conservation must be implemented.

Figure 1: Map of Pncima

Source: Living Oceans Society

Section 2: The Ocean Economy in Pncima

Background

The nature of B.C.'s ocean economy is changing. Faced with the volatility of world markets, unsustainable practices, mismanagement, and environmental degradation, the once-dominant primary industries – forestry and fishing – are in decline. Replacing them are industries such as fish farms and offshore oil and gas drilling that may provide short-term economic boosts but at the expense of the marine ecosystems and environments they actually rely on. An attempt to better understand and protect Pncima's ocean ecology and economy necessarily involves a fuller understanding of all the contributions the ocean economy provides.

A robust financial assessment of Pncima, quantifying all of the direct, indirect, and induced financial impacts generated by the ocean economy, would be ideal but is beyond the scope of this analysis due to time and resource constraints. This section will provide an economic scan, essentially a snapshot of selected cities, towns, villages, and municipal districts in Pncima. While both Statistics Canada and B.C. Statistics provide some excellent overviews of certain industries and occupations, they do not separately document all the oceanic industries and occupations that drive and support communities in Pncima. Presumably because many of the northern coastal communities of British Columbia are remote and sparsely populated, the federal and provincial governments have not yet had the resources, or perhaps the inclination, to fully assess the direct, indirect, and induced economic impacts of the region.

One study by GS Gislason & Associates, *Economic Contributions of the Oceans Sector in British Columbia*, recently attempted to quantify the various industries associated with the ocean economy. This analysis, however, relied on government statistics and was therefore limited to looking at the financial contributions of the province's ocean economy in terms of broad regions – the entire North Coast, Lower Mainland, and Vancouver Island.[1] While this approach relied on quality data from reputable sources, the drawback was that the analysis only dealt with vast regions of the province and a more industry-specific analysis is not readily available.[2] Another study uses the grounded theory approach, a useful qualitative analysis tool providing important contributions to a fuller understanding of B.C.'s ocean (Pacific Analytics, 2008), but it does not detail precisely the financial value and impact the ocean's economy provides.

Pncima Valuation Exercise

Given the statistics that are readily available, it is possible to provide a snapshot of what the impacts look like for a number of communities, including First Nations

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[1] This report primarily uses the total direct/indirect and induced impacts as defined and calculated in the *"Economic Contributions of the Oceans Sector in British Columbia"* (GSGislason and Associates Ltd. 2007).
[2] CANSIM may provide all or a portion of the data needed for this type of analysis, but for a fee.

communities. This analysis will be broken down into two tiers. The first tier analysis will provide a general overview of the economic contributions of 35 communities in Pncima, including all the industries and consequently varied occupations within these communities.

A second-tier analysis will provide a more detailed description and analysis of nine specific communities of varying size – Alert Bay, Campbell River, Central Coast[3], Masset, Port Alice, Port Hardy, Port McNeill, Prince Rupert, and Sayward.[4] These communities are encompassed within four Regional Districts – the Central Coast, Skeena-Queen Charlotte, Mt. Waddington, and Comox-Strathcona. Some of the district borders may extend beyond the boundaries of Pncima, but all the communities examined fall within Pncima. Table 1 below shows the communities and the districts to which they belong:

Table 1: Regional Districts and Communities in Pncima

Regional Districts	Communities
Central Coast[5]	Bella Bella (Reserve) Bella Coola (Reserve)
Comox-Strathcona	Campbell River (City) Sayward (Village)
Mt. Waddington	Port Hardy (District Municipality) Port McNeill (City) Port Alice (Village) Alert Bay(Village)
Skeena-Queen Charlotte	Prince Rupert (City) Masset (Village)

Methodology & Discussion Tier 1

This analysis is meant to provide a rudimentary overview of the financial contributions from the ocean-related industries of 35 communities located in Pncima. Table 2 lists the populations (2001 and 2006), median incomes (before and after taxes), total labour force, occupations, and industries of these communities. Table 3 lists the median income (2006), total labour force, occupation, industry, total occupations income, and total industry incomes of the same communities. Multipliers have not been used as all the communities' industries and occupations are being included. A brief analysis of these figures provides several insights into Pncima.

[3] For the purpose of this study the Central Coast refers to the communities of Bella Bella and Bella Coola.
[4] All the numbers and data for these communities may be found online at Statistics Canada's 2006 Community Profiles.
http://www12.statcan.ca/census-recensement/2006/dp-pd/prof/92-591/index.cfm?Lang=E
[5] Bella Bella and Bella Coola are not examined on an individual basis as the other communities are. The statistics that would permit such an analysis do not exist. However, Bella Bella and Bella Coola are the major population centres of the region and both are situated in Pncima. Therefore, bearing this caveat in mind, these communities are used as representative of the Central Coastal communities of Pncima.

- Since 2001, many of the communities have declined in population – on average four per cent in Pncima, compared to a five per cent growth rate for the province.
- Pncima accounts for roughly two per cent of the population, occupations, and industries in B.C.
- Approximately $900 million in occupational income is generated in Pncima. This equates to two per cent of provincial occupational income.

Methodology & Discussion Tier 2

This study estimates the contribution of the total direct, indirect, and induced impacts of three industries on the gross domestic product (GDP), labour income (LI), and employment years (EY) for the respective industries. The three industries examined are seafood, forestry, and public administration. These industries are extracted from the list of industries addressed in the aforementioned GSGislason & Associates study, which includes seafood, forestry-marine component, marine construction, ship- and boat-building, ocean-related high technology, ocean recreation, ocean transport, public administration, non-government sectors, and potential energy development. All these occupations are dependent, to varying degrees, on the health of marine and coastal ecosystems. The subset of industries addressed in this section was determined by their presence in Pncima and by available data. Each industry is defined by the North American Industry Classification System (NAICS) used by Statistics Canada. These three sectors and their subsidiaries, identified below, by no means represent the only direct, indirect, and induced financial benefits generated by the ocean economy in Pncima. However, for the size and scope of this project they are the most suitable and it is expected that they will yield the most reliable and illuminating data.

Seafood Industry[6]

It has been estimated that the total contribution of the coastal seafood industry in B.C. to the provincial GDP, LI, and EY is $1,300 million, $815 million, and 21,570 respectively. Due to the lack of data and the vast array of occupation and subsidiary industries, this was an extremely difficult industry to classify and analyze at the community level. It comprises vessel owners, masters, deckhands, fish processors and packers, and fish-farm owners and employees, to name a few. Often vessels used to harvest a catch in one region, perhaps Campbell River, are registered and berthed in another, such as Vancouver or Victoria. The salaries and wages vary tremendously, as does the duration of employment, which ranges from part-time or seasonal to full-time. Bearing these caveats in mind, it is assumed that all employees work a 12-month year and all are paid the same average wage.

[6] All figures are calculated using 2005 figures, unless otherwise specified.

Employment Years
The number of EYs was calculated by dividing the BC Stats Community Profile category Fishing and Fish Processing (Special Aggregations) by the total number of Seafood Industry jobs (21,570) in coastal British Columbia. For example, Prince Rupert has 880 employees in the Fishing and Fish Processing industry[7]. The equation then is:

(1) 880/21,570 = 0.04 or 4%

Table 2 shows the average percentage of employment contributed by each community to the industry province-wide.

Table 2: Employment Years for the Seafood Industry in Pncima

Community	Percentage Total Industry (BC)	Percent of Employment Years (by community)
Alert Bay (40)	0.19%	12%
Campbell River (340)	1.58%	2%
Central Coast (170)	0.79%	27%
Masset (30)	0.14%	6%
Port Alice (0)	-	-
Port Hardy (265)	1.2%	12%
Port McNeill (95)	0.44%	8%
Prince Rupert (880)	4.1%	12%
Sayward (30)	0.14%	21%

Labour Income
According to BC Stats, in 2001 the direct impacts of the seafood industry – consisting of commercial fisheries, aquaculture, fish-processing, and sports fishing – generated $333.4 million (BC Stats, 2002). There are 12,970 people (EY) directly employed by the seafood industry (GIGislason & Associates, 2007). Therefore, to calculate the average salary for the industry one can divide the total salaries generated by the number of employees in the sector:

(2) 333,400,000/12,970 = 25,705.47

If one were to include all the indirect and induced impacts into the equation it would increase the number of employees to 21,700, and the formula becomes:

(3) 333,400,000/21,700 = 15,364

If one multiplies this annual salary ($15,364) by the number of employees in the sector then divides the total LI for the seafood industry ($333.4 million) one gets an

[7] BC Stats Community Facts, using NAICS labour definitions.

approximate value of Pncima's communities' share of the industry. Campbell River has 340 employees, so the equation is:

(4) (340 x 15,364)/333,400,000 = 0.0156 or approximately 1.6%

Table 3: Labour Income for the Seafood Industry in Pncima

Community	Percentage Total Industry (BC)	Percent of Labour Income (by community)
Alert Bay (40)	0.18%	12%
Campbell River (340)	1.6%	2%
Central Coast (170)	0.78%	27%
Masset (30)	0.14%	6%
Port Alice (0)	-	-
Port Hardy (265)	1.2%	12%
Port McNeill (95)	0.44%	8%
Prince Rupert (880)	4%	12%
Sayward (30)	0.14%	21%

Forestry

It has been estimated that the total contribution of the coastal forestry industry in B.C. to the provincial GDP, LI, and EY is $262 million, $162 million, and 3,030 respectively. Due to certain constraints, discussed above, many of the same assumptions are made as in the seafood industry. All employees are considered to make the same average salary and work a full 12 months. Employment type within the industry also varies greatly, including but not limited to fallers, heavy-machine operators, mill workers, etc. With these caveats in mind, the percentages are explained below.

Employment Years

The number of EYs was again calculated by dividing the BC Stats Community Profile category Forestry and Forest Products (Special Aggregations) by the total number of coastal logging jobs (3,030)[8] in British Columbia. For example, Port Hardy has 280 employees in the coastal logging industry[9]. The equation then is:

(5) 280/3,030 = 0.0924; approximately 9%

Table 4 shows the average percentage of employment contributed by each community to the coastal industry.

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[8] This number refers to all the direct, indirect, and induced impacts realized by the forestry sector, as used by GSGislason and Associates Ltd. 2007.

[9] BC Stats Community Facts, using NAICS labour definitions.

Table 4: Employment Years in the Coastal Logging Industry in Pncima

Community	Percentage Total Coastal Industry 2005 (BC)	Percent of Employment Years (by community)
Alert Bay (20)	0.7%	6%
Campbell River (2080)	69%	11%
Central Coast (55)	1.8%	9%
Masset (45)	1.5%	8%
Port Alice (35)	1.2%	8%
Port Hardy (280)	9%	12%
Port McNeill (445)	15%	38%
Prince Rupert (235)	8%	3%
Sayward (15)	0.5%	11%

The figures suggest that a discrepancy exists between the number of coastal employees as determined by the GIGislason Report and BC Stats', which in fact there is. While BC Stats accounts for all those employed in the province regardless of whether or not they are associated with the coastal industry of the Mainland or the more Interior regions, the GIGislason figures are more concise and account for those impacts that are associated solely with the coastal sector. This is the biggest assumption and, of course, limitation in this particular study – that all the figures used from BC Stats are considered to be related only to the coastal industry and not from any other area, like the Interior of the province. This assumption is made out of necessity as the resources are not available to discern exactly the impacts related to coastal activity as opposed to provincial.

The actual coastal contribution to the forestry industry – including logging, wood products, and pulp and paper – has been estimated at roughly four per cent (4.25%) of the total provincial industry (GIGislason, 2007). Assuming this is true, one may use a multiplier of 4.25 per cent on the employment numbers given for each community. For example, as Port Hardy has 280 EYs then the formula is:

(6) $280 \times .0425 = 11.9$ or 12.

This equation will yield a much lower but likely more realistic estimate of the contribution Pncima's communities make to the forestry sector.

Table 5: Employment Years for Coastal Logging in Pncima

Community	Percentage Total Industry (BC)	Percent of Employment Years (by community)
Alert Bay (1)	0.03%	0.3%
Campbell River (88)	3%	0.5%
Central Coast (2)	0.07%	0.3%
Masset (2)	0.07%	0.4%
Port Alice (2)	0.07%	0.4%
Port Hardy (12)	0.4%	0.5%
Port McNeill (19)	0.63%	2%
Prince Rupert (10)	0.33%	0.1%
Sayward (1)	0.03%	0.7%

Labour Income

Though BC Stats provides an average 2005 weekly salary for those in the forestry, fishing, and mining sectors, it is possible to estimate the average salary in the forestry sector using earlier figures from the GIGislason study and the 2001 census. The LI for the entire coastal logging industry in 2002 has been estimated at $157 million (GIGislason, 2007). In 2000, the average yearly salary of those employed in the forestry sector was estimated at $38,400 (Census 2001). Multiplying the average yearly salary by each community's labour force, once having multiplied by 4.25 per cent, then dividing that total by the coastal total forestry LI ($157 million), will give the percentage each community contributes to the coastal sector. For Campbell River the formula would be:

(7) [(2080 x 4.25%) x 38,400]/157,000,000 = 2.2% or 2%.

Table 6, below, shows the percentage share of each community.

Table 6: Forestry Labour Income in Pncima

Community	Percentage Total Industry (BC)	Percent of Labour Income (by community)
Alert Bay (1)	0.02%	0.3%
Campbell River (88)	2%	0.5%
Central Coast (2)	0.05%	0.3%
Masset (2)	0.05%	0.4%
Port Alice (2)	0.05%	0.4%
Port Hardy (12)	0.3%	0.5%
Port McNeill (19)	0.5%	2%
Prince Rupert (10)	0.2%	0.1%
Sayward (1)	0.02%	0.7%

Public Administration

It has been estimated that in 2005 the combined total impact of federal and provincial government public administration on coastal B.C. to the provincial GDP, LI, and EY is $989 million, $853 million, and 13,460 respectively (GIGislason, 2007). The number of employees in each town working in the public administration sector was taken from BC Stats Community Profile category Public Administration[10].

<u>Employment Years</u>

The number of EYs was again calculated by dividing the BC Stats Community Profile category Public Administration by the total number of coastal public administration jobs (13,460) in British Columbia. For example, Prince Rupert has 465 employees in the coastal public administration sector[11]. The equation then is:

$$(8)\ 465/13{,}460 = 0.0345;\ \text{approximately } 3.5\%$$

Table 7 shows the average percentage of employment contributed by each community to the coastal industry.

Table 7: EY Public Administration Pncima

Community	Percentage Total Industry (BC)	Percent Total Industry (Pncima)
Alert Bay (85)	0.63%	25%
Campbell River (675)	5%	3.5%
Central Coast (240)	2%	39%
Masset (85)	0.63%	16%
Port Alice (30)	0.22%	7%
Port Hardy (115)	0.85%	5%
Port McNeill (115)	0.85%	10%
Prince Rupert (465)	3.5%	6%
Sayward (20)	0.15%	14%

The greatest limitation in this calculation is that the BC Stats numbers include all those who worked in the sector, including municipal and aboriginal governments, while the GIGislason report only uses coastal public administration employees. The GIGislason report also relies on qualitative evidence to discern how many people work solely on coastal public administration matters. While not unreliable, for the purpose of this study an actual numerical figure indicating exactly how many people worked in the coastal public administration sector would be optimal.

[10] This category includes more than just federal and provincial employees. According to the NAICS 2007 definition it also encompasses municipal and Aboriginal government employees. This caveat will be discussed below.

[11] BC Stats Community Facts, using NAICS labour definitions.

Labour Income

The average weekly salary of those working in the public administration sector of British Columbia in 2005 was $952.45 (BC Earnings and Employment Trends, 2008), which amounts to an annual salary of $49,527 if one assumes these workers are employed 12 months of the year. If one multiplies this annual salary by the number of employees in the sector, then divides the total LI by the total coastal public administration LI ($853 million) one gets an approximate value of Pncima's communities' share of the industry. Campbell River has 675 employees, so the equation is:

(9) (675 x 49,527)/853,000,000 = 0.0392 or approximately 4%.

Table 8: Labour Income in Public Administration in Pncima

Community	Percentage Total Industry (BC)	Percent Total Industry (Pncima)
Alert Bay (85)	0.5%	25%
Campbell River (675)	4%	3.5%
Central Coast (240)	1%	39%
Masset (85)	0.5%	16%
Port Alice (30)	0.17%	7%
Port Hardy (115)	0.7%	5%
Port McNeill (115)	0.7%	10%
Prince Rupert (465)	3%	6%
Sayward (20)	0.12%	14%

The major limitation of this study is that more than just coastal employees are included in the calculations. Public administration in any Pncima community involves more than just oceanic issues, but these figures cannot be disaggregated further given the time and resources available.

Key Findings

Some key Tier 2 findings can be extracted from the preceding exercise. These findings gain significance when one considers the Tier 1 findings; most notably, that Pncima's population is declining and currently represents just two per cent of the province's population. When this is coupled with Tier 2 results, the vital importance of ocean-based industries is readily apparent.

- Residents of Pncima depend on ocean-based industries, with average employment years (for the sectors examined) six to 60 per cent higher on the coast than the B.C. average.
- The seafood industry represents up to one-quarter of employment income in Pncima communities.
- Public administration represents up to approximately 40 per cent of employment income on the Central Coast.

Section 3: Marine & Coastal Ecosystem Services

"How inappropriate to call this planet Earth, when clearly it is Ocean."
Arthur C. Clarke

This section articulates key goods and services provided by marine and coastal ecosystems. It is divided according to the MEA framework; that is, by provisioning, regulating, cultural, and supporting services. As much as possible, each section addresses: (1) what the service/good is and how it is provided by the marine environment, (2) why it is important to society, (3) how it is represented in Pncima, and (4) what current research is telling us about this service. Available information covers the span of services unevenly, with abundant research on some services (e.g., provisioning of seafood) and limited investigation of others (e.g., aesthetic services).

Provisioning Services

Provisioning services include all the products people obtain from ecosystems, such as food, fuel, and fibre. These services are often well represented in the marketplace, with clear indicators of their monetary value. This class of services has often been artificially replicated, or manufactured, but usually with limited knowledge of its effects. In many cases, an attempt to artificially bolster one service has negative repercussions on others. For instance, although aquaculture is a thriving industry worldwide, it can support and spread water-borne diseases, harming native flora and fauna and potentially impacting other services, such as the provision of fresh water and disease regulation.

Wild & Cultured Seafood

What is it and how is it provided?

Covering approximately 70 per cent of the Earth's surface and accounting for 99 per cent of the Earth's living space, the ocean offers a diverse range of habitats for plants and animals. Although the number of life forms residing in the oceans is undetermined, we know there are at least as many aquatic species as there are terrestrial species and potentially as many as five million (MEA, 2005; FAO, 1998; Pimbert, 1999). Of this number, humans consume a small proportion of fish, shellfish, roe, and seaweeds. Wild and cultured seafood refers to any sea animal or seaweed that is suitable for consumption by people. This includes all food obtained for commercial and non-commercial purposes.

Why is this service important?

Food provisioning is one of the most important services derived from coastal and marine ecosystems. Seafood nourishes us, employs us, offers recreational activities, and plays an important role in many religious and cultural ceremonies. In addition to their health, social, and economic benefits, certain populations of edible marine life make vital contributions to other ecosystem services, thus offering unseen, indirect benefits as well.

More than one billion people worldwide, or one-sixth of the global population, rely on fish as their main source of animal protein (MEA, 2005). In 2000, marine and coastal fisheries accounted for 12 per cent of world food production, worth over US$124 billion and employed (directly and indirectly) approximately 200 million people (UNEP, 2006; FAO, 2004). Aquaculture, the farmed production of seafood, is the fastest-growing sector of animal-food production. The industry was worth US$57 billion in 2000 and represented 30 per cent of total fish consumption worldwide (UNEP, 2006). Millions more enjoy subsistence and recreational fishing. And coastal populations worldwide take pride in their local seafood, many species of which are embedded in cultural norms and ceremonies.

In addition to these noticeable benefits are others that are less discernable, yet of considerable significance. Fish populations play a vital role in the maintenance of marine and coastal ecosystems by regulating food-web dynamics and nutrient balances, sediment processes, and carbon flux. They may also act as environmental barometers and as links between ecosystems (Holmlund and Hammer, 1999). If the current trend of declining fish stocks continue, we may lose much more than just fish and, in fact, threaten the very life support functions we rely on.

The benefits in Pncima

The waters off the coast of British Columbia support more than 80 species of finfish, shellfish, and aquatic plants that are harvested for commercial, recreational, cultural, and subsistence purposes. The abundance of edible species is reflected in the range of commercial fisheries operating in the province. There are now commercial fisheries for clams, crab, eulachon, geoduck, green and red urchin, groundfish, halibut, herring, octopus, prawn, sablefish, salmon, sardine, shrimp, and tuna (DRAFT Advisory Process, 2007). The salmon and shellfish aquaculture industries are growing quickly in B.C., and currently account for 20 to 30 per cent of the total volume of harvested species. In 2005, the provincial seafood sector reported $1,380 million in revenues, employed approximately 12,900 people[12], and contributed $790 million to provincial GDP (GSGislason & Assoc., 2007). When one adds in indirect and induced impacts, or the ripple effects, of the industry, these figures increase an average of 70 per cent[13].

Looking at Pncima specifically, the seafood industry makes a significant contribution to the labour income of most communities (see chart below), most notably in Sayward

[12] This number is a minimum as 12,900 full-time equivalent positions were filled, and many may have worked part-time hours.
[13] The contribution to GDP totals $1,300 million. The number of full-time equivalent years of employment increases to 21,570, and the wages and benefits rise to $815 million. (GSGislason & Associates Ltd. 2007)

and the Central Coast, where approximately one-fifth to one-quarter of employment income is derived from the sector.

Table 9: Labour Income in the Seafood Industry in Pncima

Community	Percentage Total Industry (BC)	Percent of Labour Income (by community)
Alert Bay (40)	0.18%	12%
Campbell River (340)	1.6%	2%
Central Coast (170)	0.78%	27%
Masset (30)	0.14%	6%
Port Alice (0)	-	-
Port Hardy (265)	1.2%	12%
Port McNeill (95)	0.44%	8%
Prince Rupert (880)	4%	12%
Sayward (30)	0.14%	21%

The non-economic benefits of fish stocks in Pncima include First Nations' subsistence harvesting, the use of particular species in cultural, social, and spiritual gatherings, and the support of other ecosystem services. Many species, such as salmon and eulachon, have been a staple in the diet of coastal First Nations for thousands of years and have come to play a key role in cultural and spiritual ceremonies in the process. Such ceremonies often recognize the hidden role of species in the maintenance of other aspects of the marine environment. While the connections and interdependencies may not be couched in scientific terms, the indigenous residents have long been aware of food-web dynamics and ecosystem linkages.

This wide range of benefits requires a healthy marine environment for its continued provision. Of particular concern is the discrepancy between an increasing average per capita consumption of fish and the number of fish stocks that are critically depleted (MEA, 2005). In Pncima this situation is mirrored in the state of salmon stocks – a species group displaying serious health concerns, yet remaining in high demand. A recent DFO report (2007) on the state of the marine ecosystem in Pncima found that although the health and abundance of commercial species is generally well studied, the same cannot be said for non-commercial species, food-web dynamics, or the ability of species to adapt to rapidly changing environmental conditions (Lucas et al., 2007).

<u>What do we know about this service?</u>

DFO regularly collects single-species fishery catch and effort data. Some of these datasets have extensive time series. Archaeological records can go even further. Only a few fisheries target or manage more than one species (e.g., integrated groundfish fishery). Declining salmon stocks are the subject of ongoing research in B.C. The Pacific Ocean Shelf Tracking (POST) project looks at salmon and other species movement and survival. This innovative system uses acoustic listening lines and surgically implanted acoustic tags to track species migration (Welch et al., 2004) and estimate illegal, unreported, and unregulated catch in the province's salmon and groundfish fisheries. This number seems to be decreasing but is still a significant component at 8,000 tonnes or 6.6 per cent of reported landings.

Worldwide, there is a growing trend of exploiting fisheries at increasing depths (Morato et al., 2006; Roberts, 2002). Advancing technology and declines in shallow-water species have allowed new fisheries to develop in deep-water habitats. This translates to new threats to an increasing number of ecosystems, habitats, and species previously unavailable to fisheries exploitation. In B.C., fishing at greater depths is a less significant trend than in other parts of the world (Morato et al., 2006). A new fishery in B.C. based on deep-water species is the tanner crab (*Chionoecetes tanneri* and *C. bairdi)* fishery, which is currently in a test-fishery stage (Boutillier and Gillespie 2003).

Deep diversity, defined as greater than 300 metres, was identified as a data gap by the Census for Marine Life workshop "Three oceans of biodiversity" (2004). DFO conducts deep-water trawl surveys in Pncima in conjunction with the Canadian Groundfish Research and Conservation Society (CGRCS) (Stanley et al., 2007). A number of new species have been discovered since the inception of these research surveys and it is likely that this trend will continue.

Finfish and shellfish aquaculture is an area of active research. Research continues on the interactions between cultured salmon and wild salmon, including both the effect of increased nutrient load on the surrounding water and disease and parasite transmission to wild salmon. Perhaps in response to these issues, there has been a move toward integrated multi-trophic aquaculture. Integrated multi-trophic aquaculture is an ecosystem-based management approach to aquaculture that attempts to include organisms from multiple trophic levels (Chan et al., DRAFT). Vancouver Island University's Centre for Shellfish Research performs research on integrated multi-trophic culture systems under Dr. Penny Barnes. There are no commercial operations in place but there is a research operation, Aquametrix, in the final stages of preparations. Its goal is to produce commercial products (L. Hannah, DFO, pers. comm.). Aquametrix, under the direction of Dr. Steven Cross at University of Victoria, has opened an integrated aquaculture research facility in Kyuquot Sound, just outside the southern Pncima boundary on the West Coast of Vancouver Island.

There are a few examples of closed-system, land-based shellfish aquaculture operations worldwide. They are extremely expensive and research-intensive operations. The start-up costs of these operations could be used to estimate the value of the supporting services that natural marine ecosystems provide for aquaculture farms in B.C.

Fresh Water[14]

What is it and how is it provided?

Fresh water refers to bodies of water containing low concentrations of dissolved salt, such as lakes, rivers, and streams. Only a fraction of the water on Earth is fresh water, representing just 2.5 per cent of the total water supply. Approximately three-quarters of this amount is frozen, and a considerable proportion of the remainder exists as soil moisture or is deep underground (MEA, 2005). The small proportion of fresh water remaining above ground in wetlands is derived from the marine environment. Coastal ecosystems and their associated services rely upon the input of fresh water, which the oceans maintain through the processes of evaporation, condensation, and precipitation – a cyclical mechanism discussed in greater detail under "Climate Regulation" (see p. 35).

Why is this service important?

Few other elements are as universally required for life as fresh water. The linkages provided and sustained by this resource can be traced from its impact upon individual human beings to its effect upon communities, and ultimately to its contribution to large-scale ecological processes. At an individual level, fresh water is required to digest and absorb food, to provide oxygen and nutrients to the cells, and to maintain muscle tone, remove bodily waste, and cool the body as needed. At the community level, it is used for sanitation, to irrigate crops, support industry, and to generate electricity. At the broadest level, the global water cycle influences both inland and coastal wetlands, while wetlands simultaneously exert a significant influence on the water cycle itself. Wetlands can help to reduce flooding, promote groundwater discharge, and regulate river flows (WRI, 2008). Most geochemistry at the Earth's surface is mediated by or dependent on reactions involving water. For more reasons than we think, the planet would be inhabitable without water.

About 1.1 billion people worldwide lack access to a safe water supply while over 2.6 billion lack access to basic sanitation. The United Nations has set a goal of halving the number of people without access to safe drinking water and basic sanitation needs by 2015 (UN, 2002). To achieve this goal, environmental resources must be protected in the pursuit of sustainable economic development.

The benefits in Pncima

There is no scarcity of fresh water in Pncima. Estuaries, rivers, and inlets dissect and carve the entire coast, supplying water for communities and industry alike. The physical features of the coast allow for the continuous input of fresh water. The salt water of the marine ecosystem mixes with the fresh water of terrestrial ecosystems in numerous rivers, fjords, and inlets. The input and timing of fresh water into coastal ecosystems interact with ocean-wave intensity and ocean-current strength and

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[14] The water cycle plays multiple roles in the climate, chemistry, and biology of the Earth, making it difficult to classify solely under one ecosystem service. It is here grouped under provisioning services, but it is important to bear in mind that it can be justified as a component of other services as well.

direction to mix nutrient-rich waters, which feed phytoplankton blooms and thus form the base of the marine food web (Lucas, 2007). The influence of fresh water in the Pncima region is key to its unusually high biological productivity. Any sustained change to this process will eventually be seen in fish production and will impact on the provision of wild and cultured seafood, as well as the ecosystem linkages already discussed.

Groundwater plays a role in the health of fluvial fishes, most notably salmonid species, by maintaining the base flows of water and riparian habitat, regulating stream temperature, determining the size/quantity of winter refugia, and overall water quality by supplying dissolved oxygen and nutrients to streams and buffering water-quality changes through hyporheic exchange (Power et al., 1999). A study by Knowler et al. (2003) estimated the value of freshwater salmon habitat at C$1,322 to C$7,010 per kilometre of coho stream length in 1994 dollars (*in* Philcox et al., 1997). Decreasing groundwater discharge threatens these ecosystem services and may have serious economic impacts if it is relied upon for commercial purposes.

Although one-quarter of B.C. residents rely on groundwater as their primary source of drinking water, personal use ranks low on the list of key extractors of fresh water (Smerdon and Redding, 2007). Typical high-water users include agriculture, the energy sector, manufacturing, and ore/oil refineries (UN World Water Development Report, 2006). In Pncima, a few scattered agricultural land reserves (ALRs) are established in Haida Gwaii and near Kitimat (see Appendix B for map of B.C. ALRs), indicating low agricultural use. There are 10 independent power plants (IPPs) in Pncima, half of which are located in the southern boundary region (see Appendix C for map of B.C. IPPs), indicating moderate use. A low number of manufacturers operate in the more populated regions, such as Port Hardy and Kitimat, indicating low manufacturing use. Finally, there are no oil or ore refineries in Pncima. In combination, this indicates that Pncima has a relatively low water demand, which is increasingly uncommon.

Estimating the monetary value of fresh water is a daunting exercise, often capable of indicating only minimum values or ranges. An illuminating case study is the valuation of the Catskills watershed in New York City. Before becoming overwhelmed by agricultural and sewage run-off, the Catskills Mountains watershed provided New York City with high-quality water. When the water quality fell, city officials opted to invest $660 million into restoring the watershed, as it was a clear savings over the $6 to $8 billion required for an artificial filtration plant (Heal et al., 2005).

Fibre & Fuel

What is it and how is it provided?

Marine fibres and fuels are raw materials or natural processes captured from marine organisms for the purpose of construction and/or energy. Clothing, building materials, ornamental items, and (renewable) energy can all be created from the components of a healthy marine environment.

Why is this service important?

The sea provides much more than fish. It endows us with materials for heat, shelter, clothing, and decoration, creating employment opportunities in the process. Some of these goods satisfy basic needs, with their valuation well established in the market. Others hold incredible potential to steer or influence the regional economy, suggesting their value will continue to rise.

The sea has provided basic provisioning materials to coastal communities for centuries. The skin of marine mammals for clothing, gas deposits for energy production, lime (extracted from coral reefs) for building construction, and the timber of mangroves and coastal forests for shelter are some of the more familiar uses of marine organisms. Raw marine materials are utilized for non-essential goods as well, such as shells and corals in ornamental items. Each of these uses is capable of being represented in the market and providing a means of income, but the one drawing considerable attention at present is renewable energy.

With the growing threat of climate change, the search for renewable sources of energy has led many to the oceans. There are approximately 6,000 offshore oil and gas installations in operation across the globe, providing 25 to 30 per cent of the world's energy supply (UN, 2002a). Offshore wind farms are also an option for regions that typically experience strong winds, such as the Hecate Strait in Pncima, and emerging possibilities attempt to capture the power of marine ecological processes. There are three ways that the power of the sea can be captured for energy, according to Energy Quest, an educational website of the California Energy Commission (http://energyquest.ca.gov/story/chapter14.html). Wave power uses the motion of waves to drive a piston or spin a turbine that can power a generator. Tidal power captures water at high tide and draws energy as it rushes out, whereas ocean thermal energy conversion capitalizes on temperature variations between surface water and deep water, capturing the energy from the exchange of heat. Currently, the costs associated with the required infrastructure for transporting ocean energy are high and operations are mostly experimental, but proponents argue that this source of renewable, predictable, constant energy will drive down costs in the long run. If this is the case, ocean energy may become the new resource industry of coastal communities, but it must be balanced with considerations of harmful impacts these new energy-extraction methods may have on the surrounding coastal and marine environments.

The benefits in Pncima

The marine and coastal ecosystems of Pncima have provided local residents with fuel and fibre for thousands of years. Wood from the coastal rainforests has been used to build innumerable dwellings, while baleen or whalebone was the precursor to plastic. More recently, the use of tidal power is under examination. These products and services have brought shelter and warmth, income, and in some cases, a medium for expressing spiritual and cultural beliefs.

The coastal rainforests have a strong connection to the sea and can be considered part of the coastal ecosystem. Lumber from coastal forests has been used to build homes, community centers, boats, canoes, and artifacts of cultural significance to the local First Nations, such as totem poles. Local artisans have also used coral reefs and shells from coastal ecosystems in crafting art and jewellery.

The marine ecosystem of Pncima is attracting attention as a source of renewable energy. In addition to creating new jobs aimed at local residents (Matt Burns, NaiKun, pers. comm.) who suffer from a disproportionately high unemployment rate, this industry could serve as a model for climate change mitigation strategies. The full wind-power potential of the Haida Energy Field, a 2,000-km^2 area to the east of Haida Gwaii (formerly known as the Queen Charlotte Islands), is upwards of 15,000 megawatts (or 55 terawatt hours), which is roughly equal to 85 per cent of the current total production of electricity in British Columbia (Doug McClelland, NaiKun, pers. comm.). The prospective impact of these benefits is enormous and is likely to have ripple effects throughout the local economy, as well as the overall health of the marine environment.

<u>What do we know about this service?</u>

The watersheds of Pncima are home to forestry, mining, and agriculture activities; however, the effects of these activities on coastal and marine ecosystem services are not well known. Recent research has shown that marine-based nutrients may play an important role in terrestrial productivity. For example, the carcasses of salmon that return to their natal rivers to spawn and die provide nutrients that are taken up by nearby plants. Stable isotope analyses showed that salmon-derived nutrients increased growth rates for nearby trees by supplying additional nitrogen (Helfield and Naiman, 2001). Terrestrial predation by bears, eagles, and others makes up another pathway that inputs salmon-derived nutrients (Gende et al., 2002).

Energy resources in Pncima include oil and gas development as well as alternative energy sources such as wind, geothermal, and tidal. Oil and gas development is currently under a provincial moratorium, but research continues on the potential of development and its effects, as well as on oil-spill impacts. Oil-spill simulation modelling has been undertaken by Living Oceans Society (Living Oceans Society, 2007). A single offshore wind farm, NaiKun Wind Farm, has been proposed for Hecate Strait (NaiKun Wind Development Inc., 2007) and is currently in the environmental assessment stage. The US$1.1 billion project would cover approximately 100 km^2 and has a capacity of 396 megawatts. The possible effects of this development are under investigation and in particular, the impact of wind turbines on crab fisheries and on migrating sea birds is a major source of concern for researchers (K. Morgan, Canadian Wildlife Service, pers. comm.). Aqua Energy, a company out of Washington, D.C. has proposed a wave-energy power plant for installation offshore of the District of Ucluelet on Vancouver Island and is in talks with utilities about providing the Pacific Northwest with hundreds of megawatts of ocean energy in the coming decade (http://environment.about.com/od/offbeatenergysources/a/ocean_power.htm). A new alternative energy source is diesel production from microalgae (Chisti, 2007). The B.C. Ministry of Agriculture and Lands has already granted money to various projects to examine the development potential of this resource.

Biochemical & Genetic Resources

What is it and how is it provided?

Biochemical resources refer to beneficial compounds from marine organisms for medicines, pharmaceuticals, and other materials, whereas genetic resources refer to the genes and genetic information used for animal and plant breeding and biotechnology. Various compounds for use in pharmaceuticals, cosmetics, biocides (chemical agents capable of destroying living organisms), and biological materials are derived from marine and coastal ecosystems. In some cases the organism itself provides a product, such as seaweed for cosmetic purposes, whereas in other cases the organism acts as a model or a blueprint for novel products, such as the construction of fibre optics technology based on the properties of sponges.

Why is this service important?

Ocean exploration is in its infancy, yet the ocean environment is already revealing highly valuable biochemical resources. These resources are used in a variety of goods and services, including pharmaceutical products, plant-based personal-care and cosmetic goods, biologically inspired technologies, and biomonitoring (i.e., the biological monitoring of pollution). Compared to terrestrial products, marine-sourced products tend to be more highly bioactive, likely due to the fact that marine organisms have to retain their potency despite being diluted in the surrounding seawater (Kim et al., 2008). While only a portion of new products make it onto the market due to the material and technical costs (collecting and processing organisms, screening, identifying, and isolating active compounds, securing a sustainable source of the organism, obtaining a patent, etc.), the rewards can be considerable and readily justified. In addition to the economic benefits, which include lucrative royalties and significant employment opportunities (associated with each stage of the development process), there is the potential of saving, extending, or improving human lives – which are not quantified as easily.

A number of marine organisms display great promise for application in therapeutic uses, including antioxidant, antiviral, anti-inflammatory, anti-fungal, and antibiotics, as well as displaying resistance against HIV, tuberculosis, malaria, and some forms of cancer (Zewers, 2008). Some commercially available products, along with their revenues, include:

- AZT, a family of antiviral drugs is based on a group of compounds extracted from the sponge *Tethya crypta*. The annual market for this drug is more than US$50 million/year (Marinebiotech.org, 2008).
- Ziconitide is used to treat chronic pain, such as that associated with cancer and AIDS. It is a synthetic form of a compound extracted from the venom of tropical cone snails and is being hailed as a powerful, non-addictive alternative to drugs such as morphine. Annual sales were US$6.1 million and $12.5 million in 2005 and 2006, respectively (Egan, 2007).
- Pseudopterosin is extracted from Bahamian soft coral for its anti-inflammatory and analgesic properties. This compound is used in skin care and cosmetics lines and is worth $3 to $4 million/year (Marinebiotech.org, 2008).

Marine organisms have also been utilized in the design phases of new technologies, such as:

- The shell and radula (teeth) of various mollusks have informed the manufacturing of high-tech ceramics, car parts, and industrial crystals (MEA, 2005).
- Oceanic diatoms are being researched in order to understand how phosphorus uptake, metabolism, and carbon sequestration take place within marine organisms (Sagoff, 2008).

The discovery of numerous medicines and treatments can be traced back to indigenous cultures with their intricate knowledge of the local ecology. A study by Farnsworth et al. (1985) found that at least 89 plant-based medicines used in the industrial world were discovered through the study of indigenous medicine. In the search for new treatments and cures of human illness it would be wise to examine the medicines of indigenous cultures. With concurrent increases in ocean exploration and consumers of natural products, the number and diversity of these industries are likely to grow (MEA, 2005). As with energy sourced from the ocean, we must ensure that we can sustain resource extraction from our marine ecosystem.

The benefits in Pncima

Pncima is rich in biodiversity and home to several habitats of interest for genetic resources, indicating a high potential for biochemical and genetic resources. The immense genetic and biochemical diversity of marine microorganisms is only beginning to be recognized as a source of new chemical entities. Any number of local species and/or habitats could provide a source of biochemical compounds and new clues to how to cure debilitating illness and disease, as well as novel ways to structure new technologies. And while scientific exploration will continue to uncover such resources, the observation and exchange of information with First Nations may speed the process along considerably.

Habitats of particular interest for genetic and biochemical resources include the inner shelf and hydrothermal vents. Inner shelves have historically been regarded as an important source of medicine (MEA, 2005), but hydrothermal vents are quickly becoming the prized habitat for scientific investigation. Lying miles beneath the water's surface, the organisms that reside alongside hydrothermal vents have adapted to extreme pressure, temperature, and toxicity, giving them properties unlike any terrestrial life form. Recent discoveries are indicating that these organisms have a high potential for biotechnological and pharmaceutical applications (Zewers, 2007). While there are currently no known hydrothermal vents within the boundaries of Pncima – the Endeavor hydrothermal vents, which were discovered in 1982, lie southwest of the boundary – there are unexplored areas within Pncima, which may harbour the necessary conditions for such structures.

What do we know about this service?

Bioprospecting activities are occurring in marine systems around the world. Bacteria, invertebrates, plants, and other marine species are all potential sources of useful biochemical compounds. The goal of most research is to synthesize pharmaceutically important compounds. Aquaculture of tropical animals to produce the compounds of interest in an amount needed can also be a viable alternative to wild harvesting. Mayer and Gustafson (2006) reviewed the discovery of marine natural products and concluded that the rate of discovery is not slowing. The Andersen laboratory at University of British Columbia continues to search for novel compounds and collects specimens from all over the world, including B.C. For example, a number of biologically active chemicals have been discovered by examining nudibranchs in B.C. (Gustafson and Andersen, 1985).

Research programs conducted under Jeff Marliave at the Vancouver Aquarium have resulted in a successful breeding program for larval fish, which supplies display animals to other aquarium facilities. Many of the cold-water collection specimens at the aquarium are provided by local ecosystems. The spatial location and frequency of these collections vary. The aquarium's curatorial teams conduct approximately four to six multi-day trips a year to collect species from various local ecosystems. The display of these plants and animals also serves an important function in educating the local public and tourists about the diversity of B.C.'s marine ecosystems.

Table 10: Summary of Provisioning Services

Provisioning Services			
Service	**Description**	**Importance**	**Pncima**
Food	Wild and cultured seafood refers to any sea animal or seaweed that is suitable for consumption by people.	• Over a billion people rely on fish as their principal source of animal protein. • In 2000, marine and coastal fisheries accounted for 12% of total world food production, worth $124 billion and employed 200 million people. • By 2000, the aquaculture industry was worth $57 billion and represented 30% of total fish consumption worldwide.	▪ The coastal waters of British Columbia support over 80 species of harvested plants and animals. ▪ In 2005, the BC seafood sector reported $1,380 million in revenues, employed 12,900 people, and contributed $790 million to provincial GDP. ▪ Upwards of 27% of income is derived from the seafood industry in some communities.
Fresh Water	The provision of water containing low concentrations of dissolved salt, such as in lakes, rivers, streams, and underground.	• Essential for human life, and crucial for sanitation, agriculture, industry, and municipal uses. • One-quarter of B.C. residents rely on groundwater as their primary source of drinking water.	▪ Fresh water is abundant in Pncima and supplies agriculture, municipalities, independent power plants, and manufacturers. ▪ Marine and coastal ecosystems provide fresh water to Pncima residents at no cost.

Raw Materials	Marine fibres, biochemicals, and other raw materials used for the purpose of construction, creation of ornaments, decoration, and energy.	• Provision of biochemicals and materials for clothing, cosmetics, decoration, and construction. • Potential for the development of wave, tidal, and thermal energy.	▪ Raw materials have been provided to residents of Pncima for thousands of years, for uses from jewellery to housing. ▪ Enormous potential for clean energy from geothermal, tidal, wave, and biomass. ▪ A wind farm has been proposed for Hecate Strait.
Medicinal & Genetic Resources	The use of marine organisms for medicines, pharmaceuticals, and other materials, and the use of genes or genetic information for animal and plant breeding and biotechnology.	• Significant pharmaceuticals have been derived from marine flora and fauna (e.g., AZT, Ziconitide, Pseudopterosins). • Marine organisms display great promise for application in therapeutic uses, including antioxidant, antiviral, anti-inflammatory, anti-fungal, antibiotics, as well as displaying resistance against HIV, some forms of cancer, tuberculosis, and malaria.	▪ Pncima is rich in biodiversity and home to several habitats of interest for genetic resources. ▪ In particular, the inner shelf and hydrothermal vents are regarded as important sources of new medicine and genetic material.

Regulating Services

Regulating services are the benefits people obtain from the regulation of ecosystem processes, such as water purification and climate regulation. These services are not well represented in the marketplace and attempts to duplicate them with technology have been mixed. Such services occur over vast areas and are connected to a range of other services, making them virtually impossible to isolate for artificial duplication. For similar reasons, their monetary worth is not well documented.

Climate Regulation

What is it and how is it provided?

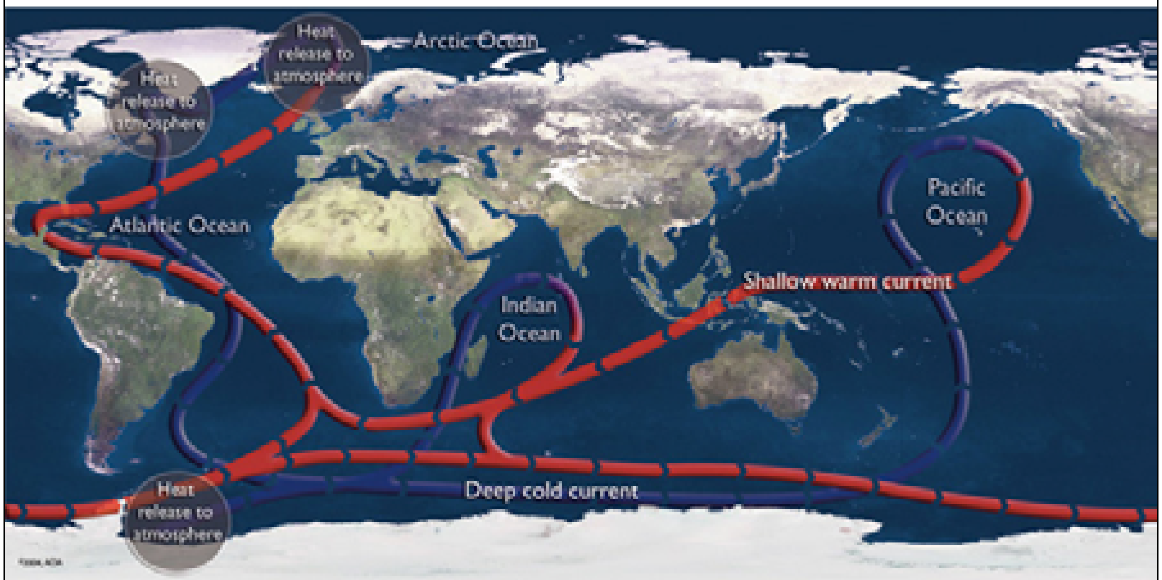
Climate regulation refers to the balance and maintenance of the chemical composition of the atmosphere and oceans by marine living organisms and chemical and physical processes (Beaumont et al., 2007). The oceans regulate climate by absorbing heat and redistributing it around the world through currents and atmospheric interactions (i.e., evaporation, condensation, and precipitation). They also absorb and chemically react with gases, such as CO_2, that cause climate modification, thus slowing down anthropogenic effects.

Why is this service important?

The ocean is a vital component of the world's climate owing to its capacity to collect, mix, and transport water, heat, and carbon dioxide. The ocean can absorb about a thousand times as much heat as the atmosphere (GESAMP, 2001). This heat is redistributed through ocean circulation from high to low latitudes by moving water from the equator to the poles, as well as from the Southern Hemisphere to the Northern Hemisphere (see figure 2). For instance, the Gulf Stream is a well-known current that moves north through the Atlantic Ocean, causing Northern Europe to be much warmer than Canadian provinces situated at the same latitudes. As currents flow, they warm or cool the overlying atmosphere through evaporation and/or the reflection of light. Given that ocean temperatures control the climate in the lower part of the atmosphere, air temperature is determined by ocean temperature for most areas of the Earth. Without the ocean, the Earth would be unbearably hot during the daylight hours and frigidly cold, if not frozen, at night.

The ocean has a crucial role to play in delaying the onset of climate change through its ability to store vast amounts of energy in the form of heat, as well as its ability to store carbon dioxide. About 90 per cent of the world's atmospheric carbon content has settled to the bottom of the ocean, where it remains stored for centuries, effectively delaying warming since CO_2 traps heat (Herring, 2008). The ocean has become the primary carbon sink over geological time, but this large-scale, slow-acting process ensures that once climate change begins, it will take nothing less than several centuries to reverse. In monetary terms, the service of carbon sequestration in wetlands has been estimated to range from $3.60/hectare/year (Olewiler 2004, amounts in 2003 dollars) to $1,360/hectare/year (Wilson, 2008) depending on the type of wetland (i.e., open water, bog, marsh, fen). Marine systems that include phytoplankton blooms and/or kelp forests would likely be even more valuable than the wetlands.

Figure 2: Ocean Currents



Source: © 2004. Arctic Climate Impact Assessment, Graphics Set 1, p. 21.

The benefits in Pncima

Because water warms and cools more slowly than land, oceans tend to moderate climates in many coastal areas. Seaside regions are typically warmer in winter and cooler in summer than inland locations. This pattern is reflected in the climate of Pncima, yet its stability is under threat from climate change.

What do we know about this service?

There is ongoing research in the field of iron supplements to marine ecosystems. Iron is often a limiting nutrient in marine ecosystems (Marchetti et al., 2006). The input of large amounts of iron can trigger productivity blooms which in turn sequester carbon from the atmosphere and potentially mitigate climate change (A. Marchetti, pers. comm.). A set of iron fertilization experiments, called SERIES, has been performed in the deep offshore North Pacific. A company called Climos is putting further effort into these large-scale experiments in an attempt to eventually sell carbon credits for iron fertilization activities on the evolving carbon mitigation market. This research is considered to be in its infancy, and many marine scientists have expressed skepticism about whether the process would remove CO_2 for the long term or just temporarily. The ecological impact of long-term, large-scale fertilization is also an unknown.

Waste treatment & disease regulation

What is it and how is it provided?

The marine ecosystem provides the service of waste treatment by removing pollutants through storage, burial, and recycling. The ability of an ecosystem to reduce waste depends upon both the properties of the waste and the properties of the ecosystem

(MEA, 2005). The marine environment has the ability to detoxify some types of waste and move, transport, or significantly dilute others. This service plays an important role in disease regulation by purifying water sources and reducing the concentration of toxics in seafood.

Waste is assimilated by oceans and wetlands through dispersion (dilution with larger volumes of water) and advection (water moving downstream) (MEA, 2005). These processes reduce the concentration of waste at the point of entry into the ecosystem. From this point, waste is further reduced through detoxification and burial. Marine ecosystems break down organic waste through microbial communities that filter water, reduce/limit the effects of eutrophication, and break down toxic hydrocarbons into their basic components such as carbon dioxide, nitrogen, phosphorus, and water (MEA, 2005). Synthetic compounds and metals cannot be readily broken down by the enzymes of microbes. Consequently, these wastes are sequestered in the sediments of marine ecosystems. Some wastes lose toxicity over time in this environment, whereas others can remain toxic for decades.

Why is this service important?

The buildup of waste in the environment can impact human health (through ailments such as diarrhea, hepatitis, and mercury poisoning), local economies (through a reduction in provisioning services), and ecosystem functioning (with dead zones representing extreme interruption). This ecosystem function will continue to grow in importance as human population increases.

Twelve million deaths per year worldwide are attributed to a lack of suitable sanitary waste treatment (Davidson et al., 1992). Although developing countries often bear the burden of water-borne diseases, developed nations are not immune to their effects. For instance, synthetic compounds can bio-accumulate in predatory fish, creating a potential hazard to human health. Communities around the world have been impacted by the effects of an overburdened ocean (e.g., mercury-laced fish, threatened water supplies, and toxic shellfish). The estimated value of waste assimilation (the removal of nitrate and phosphorus) by wetlands in the Lower Fraser Valley ranges from $452/hectare/year to $1,270/hectare/year (Olewiler, 2004; figures in 2003 dollars).

In the marine ecosystem, high levels of contamination have killed organisms (e.g., fish killed from oil spills), altered behaviour or biology (e.g., high-trophic-level birds unable to reproduce after DDT contamination), and disrupted processes (e.g., eutrophication impacts nutrient cycling). These effects can impact local economies by reducing harvest levels. For instance, antifoulant paints used on fishing boats in Europe in the 1970s decreased annual oyster production from 13,000 tons to approximately 3,000 tons over a five-year period (MEA, 2005). Eutrophication, when a body of water becomes anoxic due to an overload of nutrients, often in the form of excess agricultural fertilizer, will cause the long-term closure of commercial, subsistence, and recreational fisheries. This has the potential to destroy local economies. Worldwide, there are now at least 146 coastal areas where low oxygen concentrations occur episodically, seasonally, or chronically (UNEP, 2004).

The benefits in Pncima

Due to low population levels in Pncima, the ecosystem is believed to be capable of assimilating the waste of local communities. The same cannot be said for the waste from industrial activities on the coast, including that of fish farms, shipping traffic, and cruise ships. In addition, this service is also threatened by increasing populations, climate change, and the cumulative effects of pollution.

What do we know about this service?

There are few coastal water-treatment plants in Pncima. For the most part, water treatment for coastal communities is provided solely by the ecosystem.

Natural Hazard Regulation

What is it and how is it provided?

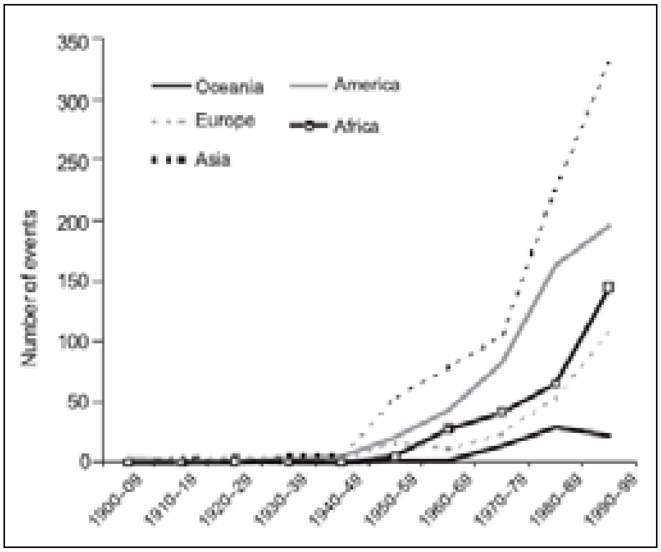
Natural hazard regulation refers to the ability of biogenic structures to mitigate environmental disturbances. Intact marine organisms act as the first line of defence for coastal regions in the event of natural hazards (such as tidal surges, storms, and flooding) by absorbing a portion of the impact and thus lessening its effect on the land. This service is provided by a diverse range of species, such as barrier beaches, coral reefs, seagrasses, and coastal forests, which act to bind and stabilize sediments, creating a natural barrier to hazards in the process (Beaumont et al., 2007; MEA, 2005).

Why is this service important?

Natural hazards are increasing alongside global warming (see figure 3), with floods and storm surges claiming responsibility for over two-thirds of the people affected by natural disasters (IFRC, 2001). Floods were the most frequent natural disaster between 1992 and 2001, killing close to 100,000 people and affecting over 1.2 billion (OFDA/CRED, 2002). The impacts of flooding, a natural hazard highly associated with marine and coastal ecosystems, are felt across health, social, and economic scales. The possibility of infectious diseases, lack of clean drinking water, loss of property, damaged infrastructure, and loss of life are all heightened with extreme weather events, which are increasing in frequency with climate change. The preservation of natural habitat will mitigate the impacts of weather hazards.

The value of natural structures and organisms in lessening the effects of natural hazards has long been overlooked and undervalued. Studies estimate the value of flood control provided by wetlands to range from $2.10/hectare/year (Olewiler, 2004; figures in 2003 dollars) to $4,039/hectare/year (Wilson, 2008). Preserving natural areas is an important strategy against the impacts of natural hazards. Local and regional ecosystem conditions can affect the magnitude and scope of particular events, as ecosystems have evolved a degree of resilience to certain disturbances. In the ocean environment, coastal and inland flooding is mitigated by barrier beaches, coastal forests and vegetation, coral reefs, and floodplains. The absence of these natural blockades tends to magnify the effects of a natural hazard.

Figure 3: Number of recorded flood events by continent and decade in 20th century



Source: OFDA/CRED 2002

<u>The benefits in Pncima</u>

The natural disasters that Pncima is most susceptible to include flooding, storm surges, sea-level rise, landslides (or debris torrents), and tsunamis (Environment Canada, 2008). These can be devastating, but healthy, intact coastal environments lessen their intensity. Forested riparian wetlands, barrier beaches, and seagrasses all act to mitigate their harmful effects. Forested mountain slopes slow and disrupt landslides, and barrier beaches and seagrasses mitigate the intensity of storm surges, flooding, and tsunamis (MEA, 2005). The importance of these natural barriers is growing alongside the increasing frequency of extreme weather events associated with climatic change.

Walker and Sydneysmith (2007) predict that conditions will become wetter during the winter and spring and dryer during summer. Heavy rainfall, coupled with an early onset of the spring melt due to warming temperatures, creates a high potential of flooding and landslides in Pncima. Sudden runoff events may threaten groundwater quality, destabilize housing, increase the incidence of auto accidents, and obstruct access to health care and emergency services (Ostry et al., 2008). British Columbia had the highest number of boil-water advisories in Canada in 2008, with 530 in place in May 2008 (ibid.). Although these events occurred primarily in the Lower Mainland and outside of Pncima boundaries, they underscore the various threats to our water supply (ibid.).

What do we know about this service?

Tsunamis strike the British Columbia coast on average once every 200 years (Clague et al., 2000). Coastal features such as beaches, bluffs, and rocks can attenuate waves and storm action. Kelp stands and eelgrass beds have also been shown to reduce the impact of waves on coastal environments (Barbier et al., 2008). Wave attenuation is best represented by nonlinear relationships so that an increase in habitat beyond a certain threshold does not increase this ecosystem service (Barbier et al., 2008). Other ecosystem services may also prove to exhibit nonlinear characteristics and this is an emerging area of research, especially important in evaluating tradeoffs between competing ecosystem services. Scientists at DFO's Institute of Ocean Sciences are active in tsunami research.

Figure 4: Summary of Regulating Services

Regulating Services			
Service	**Description**	**Importance**	**Pncima**
Climate Regulation	The balancing and maintenance of the chemical composition of the atmosphere and oceans by marine organisms, the hydrological cycle, gas absorption, and heat distribution.	• Ocean circulation ensures that temperatures on the planet's surface do not fluctuate between extreme highs and lows. • Oceans function as massive heat and carbon sinks (approximately 90% of the world's atmospheric carbon settles at the bottom of the ocean), delaying climate change.	▪ The milder climate of Pncima is thanks to the ocean's temperature moderating function, yet its stability is under threat from climate change.

Waste Treatment & Biological Control	The removal, neutralization, sequestration, and dilution of pollutants and toxins by ecosystems, and the control of undesirable populations of harmful organisms.	• The ocean dilutes toxins and transports them away from human populations, allowing us to live healthier lives. • Water is purified by wetlands and coastal forests, an invaluable service for our own water-consumption needs and ecosystem health. • Organisms evolved in specific environs in the company of other organisms and feedbacks that regulate their numbers.	▪ Coastal water-treatment plants are rare in Pncima. For the most part, valuable water purification and waste treatment for communities are provided freely by the ecosystem.
Natural Hazards Regulation	The dampening of environmental disturbances by ecosystems.	• Healthy coastal and marine ecosystems can provide protection from tidal surges, storms, and flooding by blocking and absorbing a part of the impact. • Natural hazard events are increasing in intensity and frequency. Over a billion people were affected by floods alone from 1992-2001. • Coastal and inland flooding is mitigated by barrier beaches, coastal forests and vegetation, coral reefs, and floodplains. Their absence can lead to more severe losses.	▪ Pncima is susceptible to flooding, storm surges, sea-level rise, landslides, and tsunamis. ▪ Wetter springs and winters are predicted, increasing the potential for flooding and landslides. ▪ Tsunamis strike the British Columbia coast on average once every 200 years. ▪ These hazards can be devastating without healthy, intact coastal environments to mitigate their impact.

Cultural Services

Cultural services represent the non-material benefits people obtain from ecosystems through the development of spiritual, cognitive, aesthetic, and recreational activities. The ineffable nature of these services makes them difficult to value in a quantitative manner, nor are they easily duplicated.

Spiritual and inspirational

<u>What is it and how is it provided?</u>

Marine and coastal environments provide a rich source of inspiration for art, music, folklore, national symbols, architecture, etc. Being land-based animals, humans have long regarded the natural movements, sounds, and diversity of the ocean as sources of rejuvenation and a means of obtaining a fresh perspective. It is not surprising that many religions attach spiritual and religious values to these ecosystems and/or their components.

<u>Why is this service important?</u>

A part of our cultural heritage is associated with ecosystems and landscapes. Special features remind us, both individually and collectively, of our historic roots, cultural traditions, and spiritual beliefs. These ecosystems impart a sense of continuity and an understanding of our place in the world. From a socioeconomic point of view, these interconnections assist in ensuring a sustainable livelihood for traditional societies, and the loss of these landscapes is linked to many social and economic consequences (MEA, 2005).

Most people have a need to understand their place in the universe, and their search often involves developing spiritual connections to their environments. In turn, spiritual values are placed on certain ecosystems (such as "holy" forests), on species (sacred plants and animals), and on landscape features (such as mountains). In fact, the initial impetus for biodiversity conservation among early civilizations seems to have arisen out of religious belief systems (MEA, 2005). Nature is a common element of all major religions, and has strongly influenced the use of natural resources over time. Today, the effects of industrialization, urbanization, and social, political, and institutional change have often separated people from nature, which has exacerbated the decline of many traditional belief systems. In an attempt to reverse this trend, governments around the world have created initiatives to protect natural heritage and cultural heritage conservation.

Numerous inspirational services are associated with ecosystems and natural landscapes, including books, magazines, film, photography, paintings, sculptures, folklore, music, dance, national symbols, fashion, architecture, and advertising. *Swan Lake* by Tchaikovsky, *Silent Spring* by Rachel Carson, *Water Lilies* by Claude Monet, the bald eagle as a symbol of the United States, *National Geographic*, and the Animal Planet channel all demonstrate how nature inspires us. Consciously or subconsciously, representations of natural ecosystems remind us of and reinforce our connections with nature. As fewer people experience nature directly, we inevitably rely more on these cultural associations to affect and maintain people's connection with nature.

The ability to experience and express spiritual and inspirational interactions with nature is important for the well-being of most, if not all, people. Yet this service is difficult to express quantitatively. Certain measures, such as the number of people engaged in artistic activities, the number of people engaged in growing and harvesting raw materials for religious and aesthetic purposes, willingness to pay or the price paid for products with cultural significance have all been suggested. An example of a willingness-to-pay survey was conducted in 1999 by the Economics for Environment Consultancy Ltd. (EFTEC) for Machu Picchu, which revealed a median value to enter Machu Picchu for Peruvian tourist of $20 while foreign tourists were willing to pay $30. When the total number of tourists are factored in (e.g., 400,000 in 2003), these numbers become quite a compelling argument for the importance of spiritual and inspirational services.

The benefits in Pncima

Cultural health is supported by a variety of ecosystem services. Coastal First Nations society is extensively connected to coastal and marine resources. Many of these natural resources are considered essential for the preservation of traditional culture (Garibaldi and Turner, 2004). The transfer of language and traditional ecological knowledge is sustained through this connection to the natural world. Turner (2007) estimated the number of species considered important for First Nations peoples in B.C. and came up with the following numbers: 100 animals and 150 plants are important food species, over 100 are important for materials or technology, and over 300 for medicinal uses. Many of these species have shown documented declines and are formally designated as at risk (e.g., northern abalone). Many others, however, are considered to have lower abundance than historically seen by First Nations people. The loss of these traditional resources is an issue of particular concern for this group (Turner, 2007). The incorporation of traditional ecological knowledge (TEK) would be useful in defining conservation and restoration goals.

Garibaldi and Turner (2004) set forth elements to consider when defining cultural keystone species: (1) intensity, type, and multiplicity of use; (2) naming and terminology in a language, including the use as seasonal or phenological indicators; (3) role in narratives, ceremonies, or symbolism; (4) persistence and memory of use in relationship to cultural change; (5) level of unique position in culture (e.g., it is difficult to replace with other available native species); and (6) extent to which it provides opportunities for resource acquisition from beyond the territory (e.g., trade with Interior bands). Possible cultural keystone species for coastal aboriginal peoples of B.C. include western red cedar, edible red seaweed (*Porphyra abbottiae*), wapato, five species of salmon, eulachon (*Thaleichthys pacificus*), cockles (*Clinocardium nuttallii*), abalone (*Haliotis kamtschatkana*), and sea otter (*Enhydra lutris*). The importance and use of these species vary according to the scale being used. Importance of a species can differ both between different bands and between members within the same band (Garibaldi and Turner, 2004). Cultural significance also varies temporally as many species are seasonally exploited and there have been major changes through time.

What do we know about this service?
The "Forests and Oceans for the Future" project is coordinated by Dr. Charles Menzies, an anthropologist at UBC. This project examines local ecological knowledge in order to integrate local systems of governance and resource management with conventional science.

Coastal communities in Pncima have deep cultural connections with marine resources. The histories of these communities are intertwined with natural resource development and therefore their social capital depends on natural resources. "Coasts Under Stress" was a multidisciplinary research project aimed at understanding the community dynamics of remote communities that depend on natural resources (Ommer, 2008). The project ran from 2000 to 2005 and produced a large number of publications. With declines in traditional resource industries such as fishing, forestry, and mining, many of these communities experienced restructuring toward new industries like tourism and aquaculture (Dolan et al., 2005). The coastal community of Prince Rupert was the case study for the West Coast of Canada (ibid.). Research in Alaska showed that the value of subsistence goods to coastal communities could make up 10 to 35 per cent of income and, in addition, contributed to feelings of well-being for these user groups (N. Vadeboncoeur, UBC, pers. comm.). As part of the BCCES project at UBC, this research will be expanded to look at intangible values and their effect on the community.

Other B.C. cultural groups have potentially close relationships with coastal and marine resources. For example, many Asian cultures derive their provisioning services from the sea. Efforts to locate any past or current research on the cultural values for this group in British Columbia and their dependence on marine ecosystem services were unsuccessful.

Recreation & Tourism

What is it and how is it provided?
The marine and coastal ecosystems provide opportunities for refreshment and stimulation of body and mind. Sea kayaking, beachcombing, sport fishing, surfing, whale watching, and numerous other pursuits draw people to the sea, offer health and mental benefits, and provide local employment opportunities. With increasing trends in population, affluence, and leisure time, the demand for travel and recreation within natural landscapes is likely to rise.

Why is this service important?
Recreation and tourism can provide a considerable source of local revenue, while certain forms of tourism have the potential to actually improve the state of ecosystems (MEA, 2005). Global tourism has been deemed the most profitable industry worldwide, growing up to five per cent this past decade alone (UNEP, 2007). Tourist locations situated close to the sea provide an especially idyllic setting for a range of land- and water-based sports, as well as relaxation and rejuvenation.

A growing segment of the tourism industry is ecotourism, which has been defined as tourism that *"is environmentally responsible travel and visitation to relatively undisturbed natural areas, in order to enjoy and appreciate nature (and any accompanying cultural features – both past and present) that promotes conservation, has low negative visitor impact and provides for beneficially active socio-economic involvement of local populations"* (IUCN). While tourism overall has been growing at an annual rate of four per cent, ecotourism and nature-related forms of travel account for approximately 20 per cent of total international travel (WTO, 1998), and are growing at an annual rate between 10 and 30 per cent (Reingold, 1993). This trend reinforces the importance of a healthy marine environment, which in turn can increase revenue from recreational pursuits in addition to tourist income.

Healthy marine and coastal ecosystems also offer a diverse range of activities to stimulate our physical and mental health, from kayaking to beachcombing to sampling local cuisine. In addition to health benefits, interactions with intact environments can also bring a sense of respect for nature that is difficult to obtain secondhand, through books or documentaries. Those who experience the power and beauty of our natural environments can become their strongest advocates.

The benefits in Pncima

Pncima is well on its way to becoming a key tourist destination along the Pacific North Coast. Cruise ships travelling from Washington to Alaska will increasingly stop in Prince Rupert with the expansion of the Northland Cruise Terminal. Cruise passengers are expected to increase fivefold – from 40,000 in 2001 to over 200,000 in 2011. Associated annual revenues, which are currently at $4 million, are expected to increase by as much as $30 million by 2016 (MacConnachie et al., 2007). Small, pocket-style cruise ships also travel throughout the region and predominantly cater to a growing constituency of nature-based or eco-tourists. These latter tourists are likely to contribute to recreational income in Pncima by participating in activities such as boating, fishing, kayaking, diving, skiing, hiking, and wildlife/nature tours. According to a report prepared by the Economic Planning Group (EPG, 2003), marine-based recreation contributes approximately $55 million annually to the local economy.

Pncima is an ideal location for nature-based tourism, which has ecological benefits for the region. Healthy, intact ecosystems with a high level of biodiversity are drawing a growing segment of the industry. Activities such as hiking, whale watching, scuba diving, and recreational fishing all rely on a well-functioning marine environment, and provide synergistic benefits to the environment and the local economy.

What do we know about this service?

Fisheries & Oceans Canada (DFO) conducts creel surveys each year to estimate the recreational fishing catch. Questionnaires administered at boat ramps are used to estimate catch per unit effort (CPUE) and are combined with aerial surveys to approximate the number of anglers and total effort (Kristianson and Strongitharm, 2006). This approach has its limitations, and mismatches in catch reported by fishers and that estimated by the creel survey continue (ibid.). The degree to which recreational fishing catch is underestimated as a result is unknown.

Whale watching in B.C. is primarily aimed at killer whales and incidentally at humpback and grey whales (Duffus and Dearden, 1993). A number of studies have aimed at quantifying the effect of whale-watching activities on whales. Possible effects include noise interference with sonar, direct contact with boats and propeller strikes, and alteration of normal behaviour (Duffus and Dearden, 1993; Hoyt, 2001; Duffus, 1996). Research groups at Fisheries Centre (UBC), Pacific Biological Station (DFO), Marine Mammal Group (University of Victoria), and the B.C. Cetacean Sightings Network at the Vancouver Aquarium are all dedicated to the study and protection of whales in B.C. Both the southern and northern resident killer whale stocks have been designated threatened under Canada's *Species at Risk Act* and a recovery strategy has been drafted (Killer Whale Recovery Team, 2005).

Scuba diving in British Columbia is considered to be some of the best in the world. Research by Susanne Menzel in California has quantified the value divers place on diving locations; however, similar work could be conducted within B.C.

Aesthetic

What is it and how is it provided?

People gain pleasure from natural environments all around the world. This is reflected in the use of plants and flowers as decorative elements, summer or vacationing homes in natural landscapes, and even computer screensavers depicting natural scenes such as beaches, mountains, and megafauna. Many people similarly find beauty or aesthetic value in various aspects of marine and coastal ecosystems. This is reflected in the penchant for scenic drives, vacations on the beach, and the selection of housing locations.

Why is this service important?

Contact with nature has been shown to decrease levels of stress, mental fatigue, and aggression (Hartig et al., 2003); decreased need for health-care services (Kuo and Sullivan, 2001); better health due to increased levels of activity stimulated by the natural environment (Taylor et al., 1998); improved motor development in children who regularly engage in outdoor activities (Fjortoft, 1997); and increased worker productivity and creativity (Lohr et al., 1996). In addition to these health and mental benefits of interaction with nature, economic gains are also documented, including enhanced employability; reduced criminal behaviour and decreased substances abuse by youth (Russel et al., 1998); and increased value of real estate in natural surroundings (Anderson and Cordell, 1998; Luttik, 2000).

<u>The benefits in Pncima</u>

The natural beauty of Pncima has helped shape the region's culture and has exerted considerable influence on its economy, inevitably impacting the health of its inhabitants. While there are no known studies of the aesthetic impact upon the region – economic or otherwise – most visitors or residents of Pncima will remark on its beauty. The warmth and compassion of the residents can be regarded as a reflection of the beauty of their surroundings.

Pncima has a long history of strong artistic communities, consisting of musicians, painters, craftspeople, carvers, and writers. The influence of the land is apparent in many of their works, such as Emily Carr's *Odds and Ends* (see figure 5 below), the carvings of Bill Reid, and the story of *The Golden Spruce* (John Vaillant). These and countless other artistic works have helped to form a sense of pride and identity that cannot be adequately captured by the market price of any piece of art.

Figure 5: Emily Carr's Odds and Ends, c. 1937

<u>What do we know about this service?</u>

Aesthetic services are closely wrapped up in many other ecosystem services (e.g., recreational and cultural). Studies in environmental aesthetics reveal that people display, in general, a strong preference for natural over built environments (see reviews by Ulrich, 1983; Kaplan and Kaplan, 1989; Hartig and Evans, 1993). This finding is reflected in behavioural indicators such as the higher prices paid for real estate adjacent to parks or homes with a scenic view. Coastal properties have higher real-estate value than those further away from the ocean. A study in nearby Bellingham, Washington, showed that ocean frontage adds 147 per cent to property value, ocean view adds 32 per cent, and partial ocean view adds 10 per cent (Benson et al., 1998).

This study also determined that the value of view had an inverse relationship with distance from the water.

Science & Education

<u>What is it and how is it provided?</u>

Marine and coastal ecosystems provide opportunities for cognitive development through education and research about marine organisms and habitats. Information gleaned from the marine environment can be adopted, harnessed, and mimicked by humans for a variety of purposes (Beaumont et al., 2007; MEA, 2005). This section addresses learning in both the traditional sense (known as traditional ecological knowledge, or TEK) and the formal sense (as in the western, analytic sciences).

<u>Why is this service important?</u>

Cultural and amenity services are determined entirely by human perceptions of our environment, and human perception is largely determined by the knowledge system of the community/society of which we are a part (MEA, 2005). The study of ecology, whether understood in a traditional context (e.g., through indigenous experiences) or in a formal context (e.g., as a natural science), helps humankind to appreciate the services of nature, to discern the limits and the thresholds of ecosystems, to appreciate the diversity of life, and to apply and transfer this knowledge onto the human experience.

Unfortunately, relative to the terrestrial environment, little is known of the majority of marine species and how they contribute to ecosystem processes. Most marine species have yet to be described (Butman and Carlton, 1995, Grassle, 1989). This problem is compounded by the paucity of baseline data to act as a comparison between past, pristine conditions and present, altered conditions, by the extraordinary intricacy and complexity of the marine environment and how it is influenced by large spatial scales, time lags, and cumulative effects.

<u>The benefits in Pncima</u>

Pncima is one of only a handful of relatively healthy marine environments, largely owing to its sparse human population. The region holds vast potential for scientific research, which includes traditional ecological knowledge. It is difficult to predict the benefits of research yet to be completed, but possibilities include discovering new marine organisms, a greater understanding of ecosystem processes, increased capability to chart trends, and new medicines, as well as guides/blueprints to technology.

<u>What do we know about this service?</u>

B.C. has a number of dedicated research facilities; however, few of these are located in Pncima. Bamfield Marine Station, Pacific Biological Station, Institute of Ocean Sciences, University of British Columbia, University of Victoria, Simon Fraser, and Vancouver Island University (formerly Malaspina University-College) all make use of the nearby marine ecosystems and in turn conduct research on the rich diversity of species, processes, and properties.

The Vancouver Aquarium provides a range of ecosystem services and is also dependent on ecosystem services, not least of all to feed its residents! The aquarium acts as a centre of research for scientists and education and recreation for the general public. Many of its exhibit animals are collected from B.C. waters under special permits or are donated by fishers, scientists, and divers. The aquarium's larval-rearing program mentioned in the "Genetic Resources" section also supplies specimens for other organizations.

Figure 6: Summary of Cultural Services

Cultural Services			
Service	**Description**	**Importance**	**Pncima**
Spiritual & Inspirational	Marine and coastal environments provide a rich source of inspiration for art, music, folklore, national symbols, architecture, and spiritual identity.	• Ecosystems impart a sense of continuity and an understanding of our place in the world, playing important roles in cultural traditions. • Nature is a common element of all major religions. • Ecosystems and natural landscapes inspire art, and are used in books, film, paintings, music, dance, as national symbols, etc.	▪ Coastal First Nations society is deeply connected to the coast and the ocean. Many marine and coastal resources are essential for the preservation of traditional culture. • Hundreds of marine and coastal species are valued traditionally as sources of food, medicine, and materials. • The histories of communities in Pncima are intertwined with the ecosystem around them.
Recreation & Tourism	Marine and coastal ecosystems provide opportunities for physical and mental stimulation in the natural environment through recreation and sightseeing.	• Recreation and tourism can improve the physical and mental health of participants. • Ecotourism can be a considerable source of revenue with positive impacts on the ecosystem. • Ecotourism and nature-related travel account for approximately 20% of total international travel,	▪ Pncima's healthy and intact ecosystems are characterized by high biodiversity, making it an ideal location for nature-based tourism. ▪ Tourism in Pncima is projected to grow substantially, with a five-fold increase in cruise passengers from 2001-2011 and nature-based cruises

		growing 10% to 30% annually.	growing quickly. ▪ Activities such as boating, fishing, kayaking, diving, hiking, and wildlife/nature tours are crucial to the local economy, generating approximately $55 million annually.
Aesthetic	The enjoyment and pleasure obtained from the aesthetic value of marine and coastal ecosystems.	• People gain pleasure from the natural environment, reflected in the penchant for scenic drives, vacations on the beach, and homes with a view. • Studies in environmental psychology reveal that people display a strong preference for natural over built environments. • Contact with nature has been shown to decrease stress, mental fatigue, and aggression.	▪ Pncima is a place of immense natural beauty, a valued part of its economy and an irreplaceable part of the region's culture and people. ▪ Strong artistic communities exist in Pncima, consisting of musicians, painters, craftspeople, and carvers, with many works inspired by Pncima's landscapes.
Science & Education	Marine and coastal ecosystems can promote cognitive development and the advancement of knowledge through education and research of marine organisms and habitats.	• Little is known about most marine species and how they contribute to ecosystem processes. Thus the ocean environment is a rich, undeveloped store of resources and learning with great potential.	▪ Pncima is a relatively healthy marine environment, and holds vast potential for scientific research. ▪ Marine life collected from Pncima is used educationally to inform the public about ocean ecosystems.

Supporting Services

Supporting services are necessary for and support the existence of all other ecosystem services, essentially forming their foundation. They are not represented on the market and cannot be artificially duplicated, yet their "worth" amounts to more than all of the above services combined.

Nutrient Cycling

<u>What is it and how is it provided?</u>

Nutrient cycling refers to the storage, cycling, and maintenance of nutrients by organisms and their associated processes. Cycling takes place across all ecosystems and is enabled by the diversity of biological structures, such as seabed sediments and salt marshes in coastal waters and water columns in deeper, offshore waters. These structures and their associated processes serve as buffers to constrain losses and facilitate transfers to other ecosystems (MEA, 2005).

The oceans hold vast reservoirs of nutrients, most of which sink to depths below 200 metres where there is insufficient light for photosynthesis (Dugdale, 1976). For high levels of marine productivity to occur, these nutrients must be brought to the euphotic zone through uplifting (MEA, 2005). Once at the surface, marine microorganisms such as phytoplankton absorb these nutrients and subsequently provide the base of the entire marine food web.

Why is this service important?

The efficient cycling and availability of nutrients is a precursor to life on Earth. In addition, it is necessary for ecological processes such as succession, climate regulation, and food production, and for the overall stability of ecosystems.

All living organisms contain a relatively fixed proportion of elements, most notably carbon, nitrogen, and phosphorus. Ecosystems reflect this broad proportionality of nutrient content given that the proportions of various functional groups of plants are relatively fixed. Nutrient cycles are linked by shared organic molecules that are maintained, absorbed, and decomposing at any time; therefore, a disruption to one cycle will have impacts on many others and can ultimately impact life itself.

Nutrient cycling also influences climate regulation at regional and continental scales due to an ecosystem's ability to release greenhouse gases and sequester carbon. As organisms break down or decompose, their nutrients are released or sequestered. Depending on the type of nutrient, its abundance, and the health of its associated ecosystem, it can potentially have an effect on climate systems; e.g., by the release of methane through anaerobic metabolism.

The service of nutrient cycling eventually impacts all other ecosystem services as all living things require a constant supply of nutrients to survive.

The benefits in Pncima

Pncima waters are rich in nutrients because of their geographic location on the West Coast of Canada, where equator-ward trade winds act to divert surface water away from the coast and replace it with water rich in nutrients from the sub-euphotic zone. Strong tidal mixing in the narrow passages and channels of Pncima further enhances productivity (Lucas et al., 2007). Such coastal upwelling systems are believed to constitute about one per cent of the ocean surface but contribute to about 50 per cent of the world's fisheries (Ryther, 1996). Physical characteristics such as troughs and steep edges are additional factors believed to enhance plankton and fish production.

Eddies, or circular currents of water, also play a role in nutrient cycling. It is speculated that an eddy forms over the North Bank during the winter months, mixing nutrient-rich water. When this process is combined with the Ekman downwelling, an ample supply of nutrients is made available to all water depths and may account for the ability of Pacific cod and other species to remain in the Hecate Strait-Queen Charlotte Sound throughout the winter months. (Lucas et al., 2007).

Important areas for tidal mixing in Pncima include:

- Chatham Sound and Caamano Sound (for their upwelling properties)
- McIntyre Bay and Cape St. James (for eddies that occur in these regions)
- Scott Islands (for tidal mixing)
- North Island straits and river mouths and estuaries (bottleneck areas)

What do we know about this service?

Images from the Sea-Viewing Wide Field of View Sensor (SeaWiFS) on the American Orbcom satellite are analyzed for spectral colour data to infer phytoplankton concentrations (Lucas et al., 2007).

Biologically Mediated Habitat

What is it and how is it provided?

Biologically mediated habitat refers to habitat that is provided by living marine organisms (Beaumont et al., 2007). Certain organisms provide living quarters for other marine species simply through their normal growth. Seagrass beds, kelp forests, mangroves, and coral reefs are all well-known “living” habitats of the sea.

Why is this service important?

Biologically mediated marine habitat provides a critical role in species interactions and the regulation of population dynamics. It also supports the provision of many ecosystem goods and services, including seafood, fibre, and fuel, and natural-hazard regulation (Beaumont et al., 2007).

Natural marine habitats provide breeding and nursery space for various plants and animals. These locations can also be particularly important during the juvenile stages for feeding and protection from predators. The destruction of such habitats has profound effects upon local population dynamics.

The benefits in Pncima

The natural habitats of Pncima are many, with more being discovered every decade. Habitats of recognized significance include kelps and eelgrasses, cold-water corals, sponge reefs, sea whips and pens, algae, and estuaries (Lucas et al., 2007; Clarke and Jamieson, 2006). These areas are important to various marine organisms as spawning and feeding grounds, as well as the protection of juvenile species.

Kelps and eelgrasses: Kelps and eelgrasses have been recognized as the most important macrophytes in the Pncima region (Lucas et al., 2007). They act as critical food sources for organisms residing in the nearshore environment, such as sea urchins and abalone, which are subsequently fed upon by fish and sea otters. They provide cover and shelter for crustaceans (e.g., crabs), commercial finfish at particular life stages (e.g., herring and salmon), and several species of invertebrates and finfish. In addition, by slowing currents and creating turbulence, they increase the supply of drifting phytoplankton and algae, contributing to one of the most productive ecosystems in the world. The locations of kelp forests and eelgrass beds are currently being compiled by the British Columbia Marine Conservation Analysis (BCMCA) project.

Cold-water corals and reef-forming sponges: Cold-water corals are important habitat for benthic organisms such as adult fishes, crustaceans, sea stars, sea anemones, and sponges, because they offer protection from strong currents and from predators. They are also rearing grounds for juvenile species such as rockfish. As of 2007, 61 species of corals had been identified in B.C., with as many as 50 more potential species (CPAWS, 2007). Hexactinellid sponge reefs, once thought extinct, were discovered in Hecate Strait in 1989. Found nowhere else in the world, they are currently under review for permanent protection by the Department of Fisheries and Oceans (DFO).

Sea whips and sea pens: Sea whips and sea pens are feathery animals found on soft substrates such as mud or sand, located predominantly in Hecate Strait in Pncima. They offer habitat to a diverse range of species, including worms, bivalves, sea cucumbers, commercial shrimps, several species of flatfishes, small octopuses, and squids (Alaska Marine Conservation Council, 2003). In addition, they are a source of food for sea stars and nudibranchs, and provide shelter to rockfish and crab.

Understory, turf, and encrusting algae: Algal communities are complex as they are constantly exposed to changing cycles, most notably the cycle of the tides and the penetrable depth of light. Different forms of algae can be found in intertidal, subtidal, and deep-water regions of Pncima, yet all provide a source of habitat, primary productivity, and food for various herbivorous species. Algae beds are a key habitat for herring spawn, juvenile salmon, and forage fish.

Estuaries: Estuaries are highly productive habitats as they are where terrestrial, freshwater, and marine ecosystems converge. Although they account for only three per cent of the B.C. shoreline, they are used by 80 per cent of all coastal life (NRTEE, 2005). Mackenzie et al. (2000) have identified 28 estuaries on the Central and North coast.

What do we know about this service?

The role of eelgrass beds and kelp forests in providing habitat for a variety of organisms is well documented. A newly approved proposal, called the BC Coastal Ecosystem Services project, includes a myriad of multidisciplinary research that will examine the kelp ecosystem on the West Coast of Vancouver Island. Research will focus on services provided by this ecosystem in the context of the return of sea otters, an ecological keystone species (K. Chan, UBC, Vancouver, pers. comm.). This large collaborative project has numerous investigators and a variety of field, laboratory, and modelling approaches. The interactions between kelp (a habitat-forming species), sea otters (an ecological keystone species), and abalone (a critically endangered species) will be investigated through a variety of methods. It will also examine the nutrient transfer from kelp to other ecosystems using stable isotopes.

The relatively new discovery of the hexactinellid sponge reefs in Queen Charlotte Sound (Conway et al., 1991) showcased a unique habitat structure within the Pncima ecosystem. Research is ongoing to catalogue the diversity associated with the sponge reefs and the unique habitat services they provide. Previously believed to be extinct, these reefs are now considered to be globally unique and were identified as ecologically and biologically significant areas (EBSAs) by the Department of Fisheries and Oceans (Clarke and Jamieson, 2007a).

Primary Production

Three hundred trout are needed to support one man for a year. The trout, in turn, must consume 90,000 frogs, that must consume 27 million grasshoppers that live off of 1,000 tons of grass.

-- G. Tyler Miller, Jr., American Chemist (1971)

What is it and how is it provided?

Primary production in the marine environment refers to the production of chemical energy in organic compounds by living organisms, principally through the process of photosynthesis, and secondarily through the process of chemosynthesis. This energy is employed to synthesize complex organic molecules from simple inorganic compounds like carbon dioxide and water. The result is reduced carbohydrates – relatively simple molecules that can be used to further synthesize complicated molecules. Essentially, primary production relates to the creation of new chemical compounds and new plant tissue. Over time, this results in the addition of new biomass to the system. Phytoplankton are the primary producers, or autotrophs, of the marine environment. They are, in turn, consumed by simple marine organisms, transferring their organic molecules and the energy stored within them up the food chain, ultimately fuelling the Earth's living systems (Field et al., 1998).

Why is this service important?

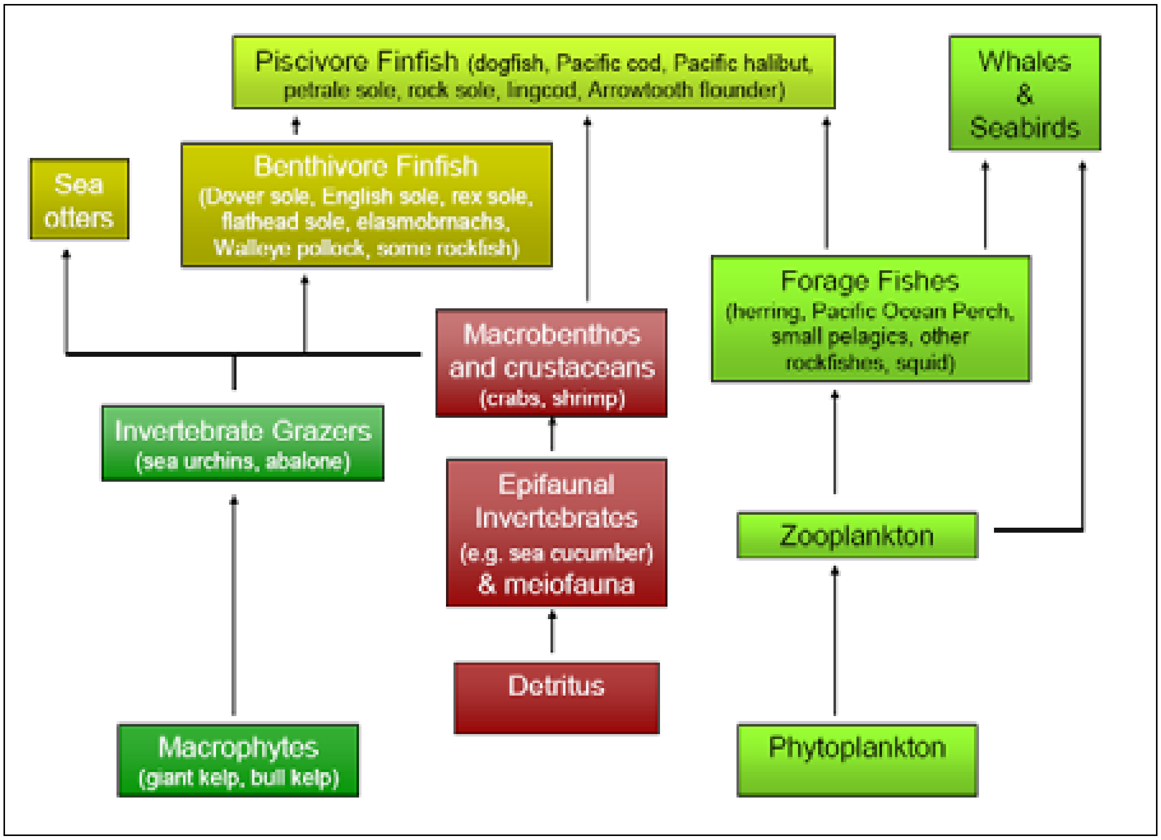
All life on Earth directly or indirectly relies on primary production. In addition to forming the base of the food web, primary production is responsible for creating oxygen and plays a key role in nutrient cycling. One cannot stress the importance of this supporting service enough, nor the impact that humankind is having on it.

Diatoms, a class of phytoplankton, are the dominant primary producers in temperate and polar oceans. Averaging only 30 micrometres in size, they are so abundant that they contribute approximately 60 per cent of the primary productivity of the oceans (Pauly, 2003). Diatoms are consumed by zooplankton, the smallest floating animals of the ocean, which are eaten in turn by small bait fish, which are eaten by the top marine predators, which are eaten by humans (see Figure 7). The removal of phytoplankton disrupts this food chain, threatening all marine life, if not all life, on Earth.

Phytoplankton require energy from the sun and nutrients from the water for the process of photosynthesis, during which they release oxygen into the water. More than half of the world's oxygen is produced in this manner. The remainder is produced on land by trees, shrubs, grasses, and various other plants.

Overharvesting, habitat alteration, marine pollution, nutrient overloading, and climate change are all having an impact on the ability of coastal and marine ecosystems to maintain primary productivity. Unaware of the threshold, or the point of no return, we are effectively contributing to our own demise with our continued degradation of the oceans. While humans cannot live without oxygen and food, the oceans will certainly find a new balance.

Figure 7: Schematic Food Webs in Pncima



Source: DFO 2007

<u>The benefits in Pncima</u>

Areas of high primary productivity tend to overlap with predominant areas for nutrient cycling. Consequently, the areas identified under nutrient cycling are also potential areas of high primary productivity. They include narrow passes and channels that experience strong tidal mixing. Eight key areas are noted, based on a 2006 report by DFO that sought to identify ecologically and biologically significant areas in Pncima (Clarke and Jamieson, 2007). Ecological structures and processes such as seamounts, shelf breaks/troughs, coastal tidal mixing, and upwelling were used to identify highly productive areas. This report failed to identify several nearshore environments, however, such as the archipelago-fjord complex, which could contain highly productive regions. The authors reasoned that such mapping is more appropriately identified through Coastal Management Area analysis, which they advised be done as soon as possible to inform the Pncima process (ibid.). This sentiment is reinforced here as high concentrations of phytoplankton occur along the coastal regions. This said, key (identified) regions of productivity include:

- Scott Islands
- Caamano Sound
- McIntyre Bay
- Cape St. James
- Hecate St. Front
- Chatham Sound
- Shelf Break
- Learmouth Bank
- Dogfish Bank

Figure 8: Summary of Cultural Services

Supporting Services			
Service	**Description**	**Importance**	**Pncima**
Biologically Mediated Habitats	Biologically mediated habitat refers to habitat that is provided by living marine organisms.	• Certain organisms provide living quarters for other marine species simply through their normal growth. Seagrass beds, kelp forests, mangroves, and coral reefs are all well known "living" habitats of the sea. • Natural marine habitats provide breeding and nursery space for various plants and animals. These are particularly important for juveniles seeking protection from predators.	• Kelps and eelgrasses have been recognized as the most important macrophytes in Pncima, serving as critical sources of food for sea urchins and abalone, and shelter for crustaceans, some species of finfish, and invertebrates. • Cold-water corals are important habitat for benthic organisms such as adult fishes, crustaceans, sea stars, sea anemones, and sponges, offering protection from strong currents and predators. • Estuaries are highly productive habitats used by salmon, crabs and other shellfish, marine mammals, and seabirds. They account for less than 3% of the BC shoreline, but are utilized by 80% of all coastal wildlife.
Primary Production	The production of chemical energy in organic compounds by living organisms through photosynthesis and chemosynthesis.	• All life on Earth directly or indirectly relies on primary production. • Diatoms, a class of phytoplankton, are the dominant primary producers in temperate	▪ Pncima contains many areas of high primary productivity, including the Scott Islands, Hecate Strait Front, Caamano Sound, McIntryre Bay, Cape St. James, Chatham

		and polar oceans. They constitute about 60% of the primary productivity of the oceans. • 70% of the world's oxygen is produced by phytoplankton.	Sound, Shelf Break, Dogfish Bank, and Learmouth Bank.
Nutrient Cycling	The storage, cycling, and maintenance of nutrients by organisms and their associated processes.	• The availability of nutrients and their efficient cycling is necessary for ecological processes such as succession, climate regulation, food production, and ecosystem stability. • Oceans hold vast reservoirs of nutrients that are cycled by uplifting to the euphotic zone. This allows their use by phytoplankton that forms the base of the marine food web.	• Strong tidal mixing in the narrow passages and channels of Pncima, which are rich in nutrients, enhances biological productivity. Such coastal upwelling systems constitute about 1% of the ocean surface but contribute upwards of 50% to the world's fisheries. • Nutrient cycling may be responsible for the ability of Pacific cod and other species to remain in the Hecate Strait-Queen Charlotte Sound through the winter.

Ecosystem Linkages

While the MEA classification of ecosystem services is useful for the purpose of depicting the range of benefits offered by the natural environment, it is important to keep in mind that they are interconnected and interdependent. In the process of balancing marine conservation with sustainable development, we must ensure that excessive damage does not occur to *any* service, as this could have far-ranging repercussions.

Figure 9: Linkages Between Ecosystem Services

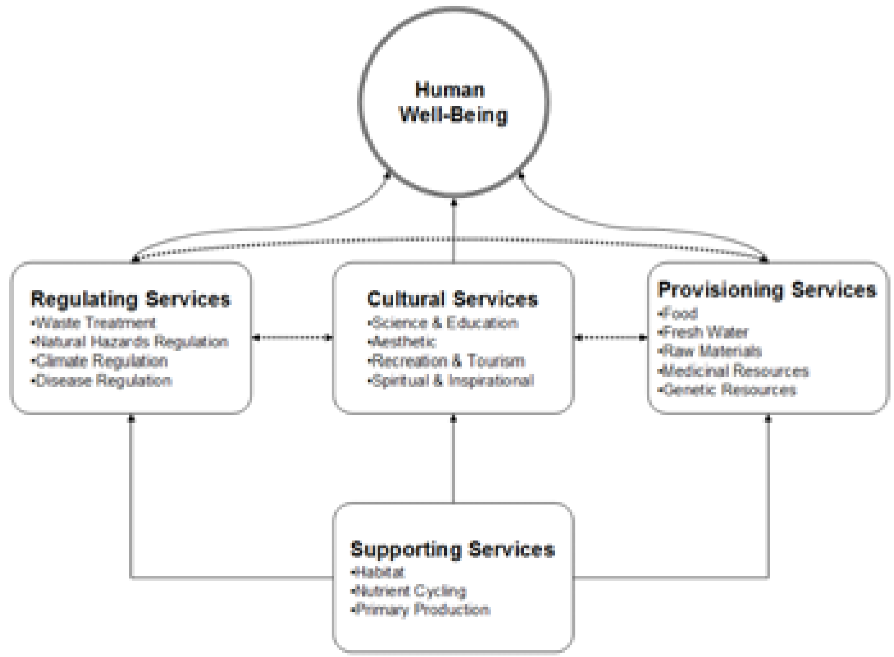


Figure 1. Depicted is a simplified diagram of the linkages between the major classes of ecosystem services: regulating, cultural, provisioning, and supporting. Supporting services underlie each of the other service categories. The relationships between services are not unidirectional and are affected by, and depend on, the characteristics and qualities of the other services. Each serves to improve human well-being.

Source: compiled by Jordan Tam (2009)

Section 4: General Research

The research described in the following section addresses broader research questions and does not fit neatly into the ecosystem services categories. We feel that the outputs of these projects could be particularly useful in addressing a number of services and their interactions.

Ecopath with Ecosim (EwE) is an ecosystem modelling software suite. EwE has three main components: Ecopath – a static, mass-balanced snapshot of the system; Ecosim – a time-dynamic simulation module for policy exploration; and Ecospace – a spatial and temporal dynamic module primarily designed for exploring impact and placement of protected areas (EcoPath with EcoSim http://www.ecopath.org). The Ecopath software package can be used to answer a number of ecological questions regarding issues such as the ecosystem effects of fishing, management policy options, and impact and placement of marine protected areas, as well as to model the effects of environmental changes. Cameron Ainsworth and collaborators (Fisheries Centre, UBC) developed an EcoPath food-web model for Northern B.C. that has similar boundaries to Pncima (Ainsworth et al., 2008). These models could be useful in evaluating certain ecosystem services indicators and function thresholds (C. Ainsworth, NOAA, pers. comm.). NOAA is using various ecosystem models, including one of northern B.C., to evaluate possible indicators of ecosystem function and thresholds that would trigger management actions (Samhouri and Levin 2008). Vastly more complex models, known as Atlantis, are also under development for various regions of British Columbia, including the Strait of Georgia. Atlantis models strive to include oceanographic, geological, and chemical properties in addition to food-web components of the ecosystem (Fulton et al., 2005).

Kai Chan and colleagues are currently reviewing the ecosystem services provided by the Great Bear Rainforest in central B.C., which is contained within the bounds of Pncima. This report was commissioned by Rainforest Solutions Project and Coastal First Nations. The authors are further examining possibilities for revenue generation by these services outside the traditional extractive goods, such as fisheries, forestry, and agriculture (K. Chan, UBC, pers. comm.). The findings of this research will likely have wider implications for marine planning in larger Pncima and British Columbia.

A report by summer intern Geneviève Layton-Cartier, in association with Natalie Ban of Project Seahorse, UBC, also examined marine ecosystem services. The research illustrated the ecosystem services that support human activities as well as those negatively affected by these activities (Layton-Cartier 2008).

A recent workshop organized by the David Suzuki Foundation in association with the University of British Columbia reviewed the ecosystem services research that has been done in Pncima and B.C., as well as ongoing or proposed projects (Clarke Murray and Klain 2008).

Research in conjunction with The Nature Conservancy examined the difference in value between forested versus harvested areas of the B.C. Central Interior (L. Hoshiaski, UBC, pers. comm.). Three ecosystem services were examined: carbon storage, timber production, and recreational angling. This study area falls partly within the watershed boundaries of Pncima.

Ed Gregr, a UBC researcher, developed a number of valuable habitat models for Pncima and B.C. A habitat template for the Pacific North Coast was designed using Southwood's habitat model (Southwood, 1977). This methodology is based on two continua spectrums: adversity and disturbance. A benthic classification scheme for Pncima in collaboration with Glen Jamieson at Fisheries and Oceans Canada is in the final stages of being completed. This research built on previous work on the Eastern Scotian Shelf (Kostylev et al., 2005). In addition, nearshore habitat patch models are being generated using a number of local datasets (E. Gregr. UBC, pers. comm.). These models would be useful in marine planning and have the potential to serve as the basis for further conservation mapping and analyses.

A proposal by UBC researchers Kai Chan and Rebecca Martone to the Packard Foundation was recently approved and will attempt to address cumulative impacts on ecosystem services in coastal and marine ecosystems and the interrelationships among impacts. Chan and Martone will model the relationship between human drivers, ecological change, and ecosystem services, explicitly incorporating uncertainty in the relationships between stressors and ecosystem services. This three-year project will also explore whether multiple stressors have a synergistic, additive, or subtractive effect on ecosystem services. Cumulative impacts of human activities on ecosystem services in British Columbia will be mapped and the project will identify the drivers that are likely to have major impacts on services and those that co-occur in areas important for ecosystem-service production.

Valuation studies

> *Valuation of the world's ecosystem services is a "serious underestimate of infinity."*
>
> \- Economist Michael Toman

A number of reports summarize and evaluate the economic value of marine systems in Canada. In a report prepared for the Canada/British Columbia Oceans Coordinating Committee, White (2001) performed an economic study of Canada's marine and ocean industries. In 1998, Canada's ocean industries contributed $10.4 billion, 1.4 per cent of the total gross domestic product (GDP). A further consultant's report estimated the economic contribution of the oceans sector in British Columbia (GSGislason &

Associates Ltd. 2007). The report estimated the ocean sector share of the B.C. economy in 2005 to be $11.1 billion, which is seven per cent of the total B.C. economy. It appears that B.C.'s economy is proportionally more dependent on marine resources than the nation's as a whole.

Traditionally, valuation exercises have focused on market-based ecosystem services. Those goods and services are directly part of the economic markets. A recent report by Philcox (2007) provides a useful framework for the valuation of non-market ecosystem services in British Columbia and examples of a small number of valuations relevant to the area. Knowler et al., (2003) estimated the value of freshwater stream habitat for coho salmon recruitment in the Strait of Georgia. Most of B.C.'s total salmon catch is taken from Pncima (MacConnachie et al.). Coho salmon stream habitat was estimated to be worth $2.63 per hectare of drainage basin or $1,322 to $7,010 per kilometre of stream length. Cameron and James (1987) estimated the value of recreational fishing to anglers on B.C.'s South Coast at $49 per day using contingent valuation analysis. A unique valuation by Sumaila et al. (2000) estimated the value that would be available if the Strait of Georgia ecosystem were restored. The authors estimated that annual profit from a restored ecosystem could be $3.796 million per square kilometre.

A valuation tool called Integrated Valuation of Ecosystem Services Tool (InVEST) has been used to model and map the distribution and value of ecosystem services (Natural Capital Project 2006). The tool aims to help researchers visualize the impacts of varying management methods, identify ecosystem service tradeoffs, and search for environmental, economic, and social capital. InVEST was designed for use with terrestrial ecosystems, but a Natural Capital Project proposal led by Kai Chan, UBC, to add coastal and marine components was recently approved (K. Chan, UBC, pers. comm.). A small pilot study as part of Natural Capital Project sought to identify perceptions of ecosystem services held by residents in the small West Coast Vancouver Island town of Tofino (Chan et al., DRAFT).Locals with a stake in environmental issues were interviewed. The results indicate that stakeholders were more likely to focus on intangible values and services, very different from those traditionally used by scientists and economists.

Nearby Puget Sound has been the focus of valuation studies in 2007. Leschine and Petersen (2007) identified a number of valuable ecological components (VECs) that provide ecosystem services. Examples included coastal forests, beaches, forage fish, and many others.

An Ecotrust project mapped the relative economic value associated with fishing grounds in California by utilizing local ecological knowledge. Ecotrust field staff interviewed individual fishermen and asked them to assign relative value to their fishing grounds. Information from the interviews was compiled by fishery, resulting in maps of the relative importance of different areas for each fishery. This information was presented in marine planning meetings to represent areas of critical importance to fishermen. The spatially explicit interview tool used in this project, OceanMap, is now available online (http://www.ecotrust.org/ocean/OpenOceanMap.html) and has been expanded to include both commercial and recreational fishing. Building trust with fishermen was essential to the successful use of this tool. Establishing this trust required extensive outreach in fishing communities before, during, and after the interviews. (S. Klain, UBC, pers. comm.).

Knowledge Gaps

The following knowledge gaps were identified in the course of this study.

Biodiversity

Canadian Census of Marine Life held a workshop entitled “Three Oceans of Biodiversity”. The participants identified a gap in the role biodiversity plays in the functioning of marine ecosystems, and thereby the provision of ecosystem services (2004). Preserving biodiversity is often one of the underlying goals of managing ecosystem services. Studies in other systems have largely demonstrated a positive link between biodiversity and the ecosystem processes that drive important services (Palumbi et al., 2009). The relationships between biodiversity and ecosystem services should be examined specifically for Pncima as these complex relationships may depend on the system in question as well as the scale of biodiversity and services examined. Causal relationships are difficult to prove but there are strong correlations between high biodiversity and production of a range of ecosystem services (Palumbi et al., 2009; Worm et al., 2006). However, a number of studies have raised the issue that the protection of ecosystem services may not always serve to protect biodiversity (Chan et al., 2007; Chan et al., 2006). Care must be taken to clarify objectives, define underlying goals, and visualize desired outcomes when evaluating management options.

Ecosystem Function

A minimum level of ecosystem “infrastructure” is necessary for ecosystems to function and produce the services we depend upon. Sometimes called “critical natural capital” the suite of processes is not well studied or understood. We often cannot predict the thresholds for ecosystem function until they have been surpassed.

Many ecosystem processes are required to derive the various ecosystem services, and we have a very poor understanding of many of these processes. For example, every fish available to be caught by a fishery is the result of a complex interplay of well-functioning processes such as larval dispersal, growth, recruitment, nutrient dispersal, food-web dynamics, predation, and competition. The end product, catch, is likely a very poor indicator of the sum of these processes and yet is the most commonly measured variable. Some authors have made distinctions between intermediate ecosystem processes, which provide supporting services (e.g., larval fish recruitment), and final ecosystem services, which are directly used by humans (e.g. fisheries production) (Boyd and Banzhaf, 2007). Under this definition, the fish population rather than the number of fish landed is the final ecosystem service. The latter is affected by effort, gear, etc. and is not a product of nature itself. Therefore we need to estimate total fish populations rather than use catch in valuing this ecosystem service.

Ecosystem service theory originated in terrestrial ecology, and the literature is often focused on terrestrial ecosystem services. Therefore marine processes are not always adequately captured in current frameworks. For instance, pollination is an important terrestrial ecosystem service. A possible corollary in the marine environment is marine larval dispersal. This dispersal depends on currents and circulation patterns, in contrast to animal pollinators in terrestrial systems. As a consequence of this wide-range dispersal, marine systems are much more widely connected geographically than terrestrial systems. This supporting process is likely an important basic function for a range of marine ecosystem services. Changes in circulation patterns as a result of climate change or small-scale changes as a result of breakwaters for harbours can affect larval dispersal at a variety of scales. The implications of these changes are essentially unknown.

Indicators & Thresholds

Once management measures are in place, monitoring must be employed to determine if conservation and ecosystem service objectives are being met. The issue of what to monitor has been met with much debate. The ideal indicators may not have enough data or money to be useful. Those indicators chosen should adequately reflect the ecosystem processes and give managers enough time to respond to change. In addition, threshold levels for each indicator should be defined to trigger management actions.

The National Round Table on the Environment and the Economy (NRTEE) 2003 developed a series of indicators for ecosystem services in Canada (mainly terrestrial). Only three of the proposed indicators were adopted (Smith 2006).

1. Air Quality Indicator* to track the exposure of Canadians to ground-level ozone (O3) and, eventually, other pollutants.
2. Freshwater Quality Indicator* to provide a national measure of the overall state of water quality (e.g., water for drinking, aquatic habitat, recreation, and agriculture).
3. Greenhouse Gas Emissions Indicator* to track Canada's total annual emissions of greenhouse gases.
4. Forest Cover Indicator to track changes in the extent of Canada's forests.
5. Wetlands Cover Indicator to track changes in the extent of wetlands in Canada.
6. Human Capital Indicator to track the educational qualifications of the workforce.

A presentation by Samhouri and Levin (2008) discussed ongoing research at NOAA and the Northwest Fisheries Center to identify indicators and thresholds of ecosystem function. They use a number of EcoPath models, including the northern B.C. model developed by Ainsworth & Pitcher. In total, 22 ecosystem attributes and 27 indicators were examined as possibilities for use in ecosystem-based management planning. Some of these indicators seem to perform better than others across ecosystem models, such as Q90 index, trophic level, and detritovore biomass. This research used multivariate statistics to distinguish complementary indictors that measure similar attributes. The results of this work could be used to inform planning and monitoring efforts in Pncima.

Cultural services

A more comprehensive catalogue of cultural services produced in cooperation with First Nations is required. "Despite a rising awareness of culture…available methods and approaches that actively address both ecological and cultural concerns are still sparse." (Garibaldi and Turner 2004). Research needs identified by Garibaldi and Turner (2004) included a catalogue of cultural keystone species and their status, community resilience in the face of environmental change, use of traditional ecological knowledge as a reference system for conservation efforts, and the interactions between keystone species and other species.

The values that British Columbians, Canadians, and international tourists place on Pncima's ecosystem services have not been addressed. The link between cultural values and marine ecosystem services is increasingly recognized for First Nations and resource-based coastal communities. However, the values of other ethnicities, cultures, urban communities, and stakeholders have largely been overlooked and need to be addressed before any planning process can begin.

Threats

Ban and Alder (2008) mapped the impacts of various human activities in B.C. This research demonstrated that the B.C. marine environment is extensively utilized. We might conclude that it also provides many ecosystem services and is under threat of overexploitation. Further research should attempt to distinguish between local, regional, and global threats. Global impacts must be addressed by international action and cooperation. In contrast, local impacts are under our direct control. Managing local impacts effectively (e.g., fishing pressure) and reducing local stressors (e.g., marine pollution) could potentially build ecosystem resilience to those impacts that are not under our direct control (e.g., climate change).

Climate Change

Climate change has been identified as one of the major threats to marine ecosystems globally (Halpern et al., 2008). Climate change has the potential to produce unforeseen changes and effects in ecosystems. Expected sea surface temperature rise and increasing ocean acidification can affect species and ecosystems in a number of ways. Research at the University of California has shown that ocean acidification could negatively affect sea urchin development (Todgham and Hofmann, 2008) and is likely to pose similar challenges for other species with calcium carbonate skeletons. Sea surface warming in combination with ocean acidification may synergistically produce stronger impacts on these species.

The productivity of Pncima is directly linked to phytoplankton production and retention (Lucas et al., 2007). Identification of ecologically and biologically significant areas (EBSAs) showed a large overlap between areas identified as important for individual species and areas of oceanographic productivity (Clarke and Jamieson, 2007a; Clarke and Jamieson, 2007b). It is unknown how sensitive this productivity will be to climate change, but modelling efforts may be able to test the type and magnitude of possible consequences. Any process or event that affects phytoplankton production or retention will have profound effects on the larger ecosystem. Research at UBC that models impacts on ecosystem services will also address climate change as one of the relevant human-mediated impacts (R. Martone, Stanford University, pers. comm.).

Ecosystem Linkages

The links between terrestrial, freshwater, coastal, and marine ecosystem services are recognized but have not been well studied in Pncima. A conference statement from Coastal Zone Canada 2008 called for the integration of research and management "from watershed to ocean" (Coastal Zone Canada 2008). Participants proposed the coastal zone as a zone of integration rather than a boundary of management activities.

Watershed activities have a largely unknown degree of impact on coastal and marine resources. Stable isotope analyses in California have shown that terrestrial nutrients are incorporated into nearshore ecosystems through storm-water runoff (Morgan et al., 2006). Worldwide, the effects of terrestrial nutrient input in marine systems have been demonstrated for coral reefs, seagrass beds, and kelp beds. Similar analyses could be performed in Pncima to determine the role of terrestrial nutrients in coastal ecosystems. As part of the BCCES project previously mentioned, the role of kelp subsidies in nearby ecosystems will be examined using stable isotope analysis (E. Pakhomov, UBC, pers. comm.).

Human activities in the marine environment can also affect terrestrial species. In B.C., the link between returning salmon decomposition and terrestrial ecosystems has only recently been documented (Gende et al., 2002; Helfield and Naiman, 2001). However, much more research is required. There is a strong need to integrate terrestrial and marine conservation planning efforts (Tallis et al., 2008).

A recent news release by the Pacific Ocean Shelf Tracking (POST) project described the migration of two salmon juveniles from the Snake River, a tributary of the Columbia River in Idaho, to the sea, then north along the continental shelf to Alaska (POST, 2008). This research finding provides an example of the connectivity of freshwater and marine habitats as well as Pncima's connectivity with geographically distant regions.

Further research using POST's established acoustic listening line network could provide insight into other species' migration routes and the scale of ecosystem connectivity.

Linkages to ecosystems external to Pncima are also largely unknown. Lucas et al., (2007) divided non-resident species into three groups: stop-over migrants, destination migrants, and environmental migrants. Stop-over migrants include migrating marine birds that rest or feed in Pncima before continuing on to their final destination. Destination migrants travel to Pncima in order to feed seasonally. These include whales and Steller sea lions. Environmental migrants extend their range into Pncima during warm conditions, such as during El Niño years. The effect of migratory species on the Pncima ecosystem is still under investigation. These species may represent a net loss or net gain to Pncima or some combination of both. The degree to which the Pncima ecosystem depends on these external ecosystem linkages is unknown.

Ecosystem Service Interactions

An example of the interaction of ecosystem services and the links between terrestrial and marine ecosystems is shown in Figure 10. The simple example of farmed salmon–wild salmon–killer whales has external links to terrestrial systems as well as other marine ecosystems. We hope that this example serves to highlight some of the complexities surrounding the management of these services, as well as a call for a move away from the management of each service in isolation. A number of ecosystem services are provided by each component. Farmed salmon provide salmon and salmon products (provisioning services). Wild salmon also supplies salmon and salmon products through commercial and recreational fisheries. The recreational fishery provides recreation services for local and tourist sports fishermen. The value of the recreational salmon fishery is unique in that it includes more than that of the actual fish caught; it is also about the value of the experience (Gende et al., 2002; Knowler et al., 2003). The five species of wild salmon are considered cultural keystone species for many coastal First Nations bands (cultural services). Resident killer whales provide recreation services in the form of whale watching. Killer whales also have existence value for a great number of people, even if they have never seen a live killer whale. Cultural services include those for coastal First Nations people who incorporate killer whales in art, stories, and ceremonies.

Even if we simply consider those services for which we have rough valuation estimates, these possibly conflicting services are worth more than <u>$1.1 billion</u>. This is a minimum since there are still large unknowns for even these fairly well studied organisms. At this time we are unable to include the cultural and existence services of wild salmon and resident killer whales. There is very little information on the exchange of energy and nutrients, via wild salmon migration, to ecosystems outside of Pncima; for instance, at increasing scales: British Columbia, Gulf of Alaska, and Pacific Ocean. There is no estimate of the value to terrestrial ecosystems because we do not have enough research to determine the relative contribution of salmon to terrestrial ecosystems and the uniqueness of this link.

To further complicate the issue, each of the ecosystem components providing the services is under the jurisdiction of different government levels and agencies (shown in green). Wild salmon is managed by Fisheries and Oceans Canada, cultured salmon is managed by the B.C. Ministry of Agriculture and Lands, and terrestrial ecosystems are managed by a variety of municipal, provincial, and national agencies, including the B.C. Ministry of Lands and Agriculture, Ministry of Forestry, B.C. Parks, and Parks Canada.

Figure 10: Ecosystem Service Interactions

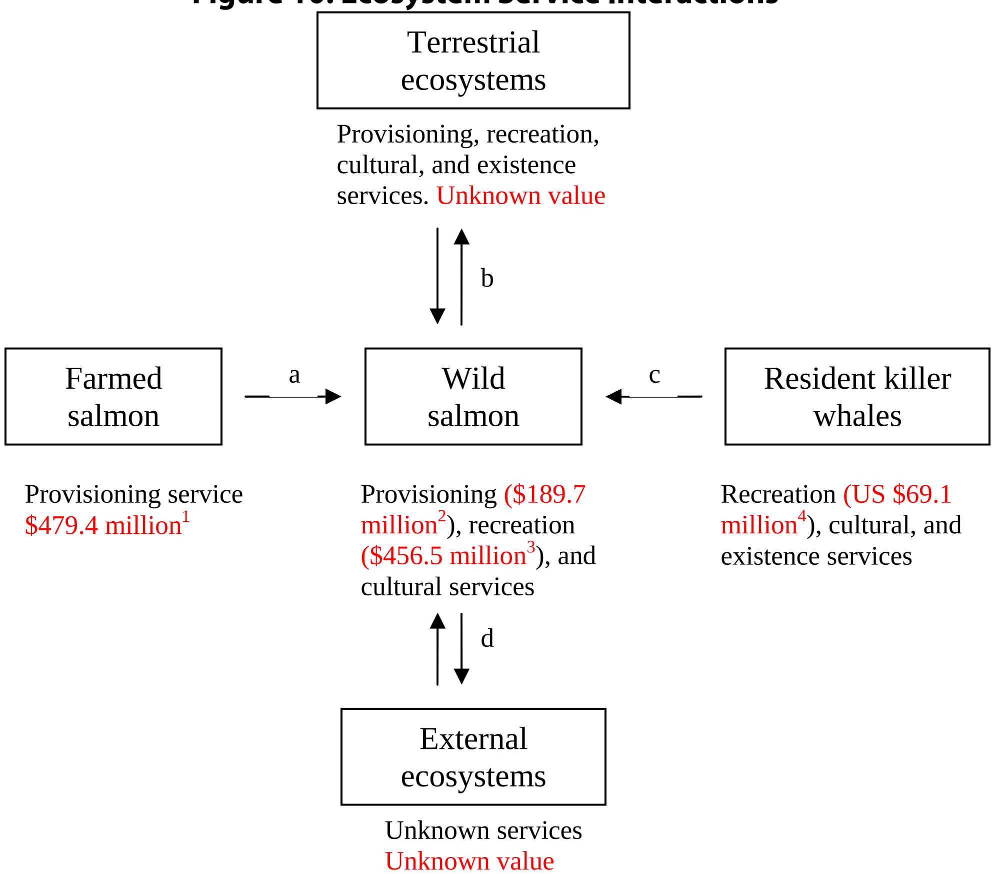


Figure 9: To illustrate the complexity of interactions between ecosystem services we have shown an example of a relatively simple and well-studied system in Pncima, with wild salmon at the centre. Even simply considering those services for which we have rough valuation estimates, the economic value of these interacting and possibly conflicting services is over $1.1 billion! Numbered footnotes explain assigned estimated values (red). Letters indicate ecological linkages between components: a – research has shown that the presence of finfish aquaculture farms has a negative effect on wild salmon, especially juveniles through disease transmission (Krkosek et al., 2007). The degree of this impact is hotly contested; b – research shows that spawning salmon bring marine nutrients into terrestrial ecosystems in the form of carbon and nitrogen converted into forest nutrients (Helfield and Naiman, 2001). The returning animals also provide food to a variety of terrestrial predators, such as bears, eagles, and wolves (Gende et al., 2002); c – resident killer whales have a diet consisting exclusively of wild

salmon (Killer Whale Recovery Team, 2005) and therefore are highly dependent on the presence of this resource; d – migrating salmon bring energy and nutrients to other ecosystems outside Pncima and also gain energy in these ecosystems and bring them back to spawning grounds, many of which are in Pncima. The areas where adult salmon spend their lives are largely unknown. POST project shows some Pncima stocks migrate north through Pncima and Alaska (POST, 2008).

[1] Wholesale value of cultured salmon in 2007 (BC Ministry of Environment, 2008). [2] Wholesale value of salmon commercial fishery in 2007 ((BC Ministry of Environment, 2008)). Data compiled by DFO and adjusted by Ministry of Environment.[3] In 2002, the tidal sport fishery was worth $550 million and wild salmon accounts for 83% of the total catch (MacConnachie et al.). Therefore, a rough estimate of the recreational salmon fishery value is $456.5 million.[4] The value of the whale-watching industry in British Columbia in 2001 (Hoyt, 2001), largely attributed to the resident killer whales as they are more reliably found in B.C. waters during summer months. Estimate includes all tourism expenditures associated with whale watching such as excursions, travel, and accommodation. (Hoyt, 2001)

Research Needs

The relative importance of research needs is discussed in Table 11. The column on spatial scale indicates whether the research need is specific to Pncima or is a need at larger spatial scales. Research status highlights whether the research need is the focus of active research, is in need of further research, or the precautionary principle should be invoked.

Table 11: General research needs identified by various sources.

Research Need (corresponds to report sections)	Canadian Census for Marine Life	Garibaldi & Turner 2004	Philcox 2007	Coastal Zone Canada	DSF-UBC Workshop	Spatial Scale (PNCIMA, BC, Canada, Global)	Research Status in PNCIMA (active, required, precautionary principle)
Ecosystem services (general)			X	X		Global	Active
Valuation				X		PNCIMA	Active
Biodiversity	X			X		PNCIMA	Required
Ecosystem Function					X	Global	Precautionary
Indicators & Thresholds			X			PNCIMA	Required
Cultural Services		X				PNCIMA	Active
Threats			X		X	PNCIMA	Active
Climate Change	X			X	X	Global	Active
Ecosystem Linkages			X			BC	Active
Ecosystem Interactions		X				BC	Active
Scale			X	X	X	PNCIMA	Required
Data poor areas	X			X	X	PNCIMA	Precautionary
Services and values			X		X	PNCIMA	Required

References:
Canadian Census for Marine Life (2004)
Garibaldi & Turner (2004)
Philcox (2007)
Coastal Zone Canada (2008)
DSF-UBC Workshop (Clarke Murray and Klain, 2008)

A summary of research needs identified during the course of the current research is presented below.

1. Integration of freshwater, marine, and terrestrial ecosystem services: Terrestrial and marine systems are connected by rivers and inlets. Therefore, activities occurring in watersheds have some degree of effect on coastal and marine

systems and vice versa. The connectedness and interdependence of these systems should be further investigated

2. Interactions between ecosystem services: Competing ecosystem services are more difficult to see in marine environment than terrestrial. Aerial photographs of changing landscapes allow us to visualize land use. Satellite photos of ocean surface cannot be used in the same way.
3. We need to modify terrestrial valuation systems and frameworks to incorporate the unique characteristics of marine ecosystems. For example, would wind pollination be the terrestrial equivalent of marine currents?
4. Single species versus ecosystem-based management.
5. Cross-boundary issues such as migrating species, import/export of ecosystem services. Management and protection needs to be international for some species.
6. Jurisdictional problems can result in the management of one ecosystem service at the expense of others.
7. Indicators and thresholds: How will we know if protection and mitigation management activities are working the way we want them to?
8. Scale: Ecosystem services operate at different scales and therefore must be managed at varying scales. "Tyranny of scale", coined by Prince (2005) to describe situations where management actions do not match the scale of ecological processes.
9. Valuations have not been done and can serve as powerful motivators for the management. Marine planning (EBM) needs quantification of ecosystem services before proceeding.
10. Cultural ecosystem services and other non-use services are not well represented in this report or further valuation exercises. Only a handful of studies have been done in B.C. Valuations are difficult to do for this suite of ecosystem services. They fall in a category of "intangible" value that is less straightforward in valuation (Chan et al., In Review).
11. Identification and mapping of cultural First Nations species, status of these species (in decline, at risk, etc), and threats to their persistence.
12. Many ecosystem processes serve to provide more than one service.
13. Supporting versus final services.
14. Response of ecosystem processes and the services that depend on them to climate change and other stressors. The precautionary approach is going to be particularly important in systems susceptible to climate change impacts.
15. Data-poor areas of Pncima and services. Data-rich services, such as fisheries, get a disproportionate amount of attention whereas other services, such as supporting and regulating, may be more critical to the long-term sustainability of the ecosystem.
16. How do science values differ from other stakeholders' values in Pncima?

Research Recommendations for Pncima

The following four research needs are highlighted as most pressing for the Pncima region:

- An ecosystem services valuation exercise for Pncima needs to be conducted. Valuations can be useful in galvanizing public support, forcing the consideration of ecosystems in cost-benefit analyses. This research should better quantify the values of B.C. residents and their priorities for the region in question.
- Evaluation of indicators and thresholds for each ecosystem service to inform management activities.
- More complete cultural services review in conjunction with FN and other cultural groups, mapping, conservation status, and threats.
- Evaluation of how to integrate varying ecosystem scales with jurisdictional scales. This is particularly important for nearshore ecosystems where the majority of supporting services occur. In particular, the mapping of ecologically and biologically sensitive coastal areas needs to be completed.

Section 5: Conclusion and Recommendations

The concept behind ecosystem services is relatively simple. The environment provides a range of beneficial services for free that, if we had to pay for substitutes in a financial market, would demand extraordinarily high prices – trillions of dollars annually. The economy ultimately depends on these services, yet government policies often fail to recognize this. Economic development that destroys habitats and disrupts ecosystem services will create long-term costs to society that may greatly exceed the short-term benefits of development and resource extraction. Although these costs are often hidden in traditional economic accounting, they are very real and may be felt for generations.

In regard to the marine environment in Pncima, there is an acute need for policies that achieve a balance between pursuing worthy short-term economic development while sustaining ecosystem services. The Pncima planning process provides an important opportunity to determine the values and management strategies for maintaining ecosystems services. It also provides an opportunity for residents of the region to articulate and negotiate how their marine and coastal resources are to be used and maintained. While the preservation of ecosystem services is only one of many considerations in a comprehensive marine-use planning process, it is a crucial starting point, serving as the basis for economic and social development.

The concluding section of this report addresses three necessary commitments required to sustain ecosystem services. It separates what can be done at the local level from what needs international attention and cooperation, highlights key issues for consideration, and proposes additional research required to more fully inform the Pncima marine planning process and resulting management and implementation strategies.

International Considerations:

This report has presented a wide range of services that marine and coastal ecosystems provide. Some of these services are sustainable through local efforts, whereas others require international arrangements. The management of migratory species and measures to maintain the processes underlying climate regulation, for instance, demand the efforts of multiple nations. In addition, research on the role of biodiversity, ecosystem indicators and thresholds, climate change, ecosystem linkages, valuation exercises, and ecosystem service interactions will need to occur in multiple locations due to the complexity of the issues. Regardless, there is much that can be done at a local scale.

Local Considerations:

Many ecosystem services profiled in this report depend on the integrity of regional, or local, marine ecosystems. The health of local fish stocks, the quality of groundwater, natural-hazard regulation, renewable-energy options, tourism, nutrient mixing, and biologically mediated habitat are all dependent, to varying degrees, on regional resource management and decision-making. In order to sustain these services, conservation objectives need to include ecosystem services. At a high level, underlying these objectives are three key commitments:

(1) a commitment to further research
(2) a commitment to monitoring
(3) a commitment to design appropriate financing, policy, and governance structures

A Commitment to Further Research:

Lack of knowledge with respect to ecosystem services is due both to the lack of relevant data and to the multivariate complexity of the concept. Both forms of research should be pursued in Pncima. Relevant data gaps include:

- Mapping of nearshore ecosystems. In particular, the mapping of ecologically and biologically sensitive coastal areas needs to be completed.
- Mapping of cultural services.
- Mapping of traditional ecological knowledge.

The Pncima region can offer significant contributions to the research on multivariate issues. Several research projects are already underway or completed. The results of these studies should be monitored and incorporated into management plans. Active research includes:

- The EcoPath foodweb model for Northern B.C.
- NOAA ecosystem models
- Atlantis models
- Ecosystem services in the Great Bear Rainforest (Chan et al.)
- Marine ecosystem services (Layton-Cartier and Ban)
- Habitat models for Pncima (Ed Gregr)
- Cumulative impacts of ecosystem services in coastal and marine ecosystems (Chan and Martone)
- Addition of coastal and marine ecosystem components to InVEST (Chan)
- Identification of valuable ecological components (VECs) that provide ecosystem services (Leschine and Petersen)
- NOAA research on indicators and thresholds of ecosystem function
- Impacts of human activities in B.C. (Ban and Alder)
- Identification of ecologically and biologically significant areas (Clarke and Jamieson)

- Climate change impacts on ecosystem services (R. Martone)
- Role of kelp subsidies in nearby ecosystems (Pakhomov)

Lastly, it would be beneficial to examine the values Pncima residents place on ecosystem services and how these values differ from science values.

A Commitment to Monitoring:

For the above research to provide lasting benefits, there must be a clear commitment to monitoring in Pncima, and the question of what to monitor is as important as the commitment to monitor. Care must be taken to clarify objectives, define underlying goals, and visualize the desired outcomes of management activities. This will help ensure the right things are being measured.

A Commitment to Governance Structures:

The former two commitments rest on a commitment to the design of appropriate finance, policy, and governance structures. Ecosystem services need to become a factor in policy decision-making, which requires an appropriate framework and governance structure. Without appropriate institutions, research from ecologists and economists will do nothing. The following questions need to be addressed:

- What financial, legal, and other social institutions are needed to safeguard vital ecosystem services?
- What is the appropriate scale for the management of various services?
- When should the precautionary principle be employed?
- How are jurisdictional problems to be addressed?
- What are the trade-offs of economic development?
- How should freshwater, marine, and terrestrial resource management be integrated?

Conservation Objectives:

In light of the federal government's commitment to move forward with a marine planning process in the Pncima, there is a need to define and secure agreement among stakeholders, government, and First Nations in the region regarding conservation objectives for this process. Among the many objectives that will be needed we recommend that there be a suite of objectives aimed at maintaining supporting services. The rationale for this rests on the fact that supporting services provide the foundation for all other ecosystem services. Conservation objectives aimed at preserving biodiversity are recommended as the link between ecosystem services and biodiversity. This concept is the focus of ongoing research (Schwartz et al., 2000; Worm et al., 2008).

As a contribution to the discussion about conservation objectives for the Pncima, the following objectives are recommended:

- Protect ecologically viable proportions of each habitat type from the pressures of human activity to maintain ecosystem processes.
- Establish management systems that maintain the biological integrity, resiliency, and productivity of the marine and coastal ecosystems at a range of spatial scales.
- Rehabilitate underrepresented and/or rare habitat types to a state of historic functional and ecological integrity.
- Establish spatial zoning for specific industrial practices to minimize the risk and probability of human-induced disasters to important ecosystems processes and biological communities.
- Maintain primary productivity within the bounds of natural variation.
- Establish strategies to reduce the risk of negative environmental impacts from industrial activity in or near the marine environment.
- Sustain ecological and evolutionary processes within an accepted range of variability.

We take great care to measure our economic assets in detail, but we don't systematically measure our ecosystem services upon which the economy depends. It is hoped that these recommendations will assist the move to a world that recognizes that the way we manage ecosystem services is as fundamental to society as economic accounting is today.

Appendix A

Valuation Methods for Estimating Ecosystem Benefits

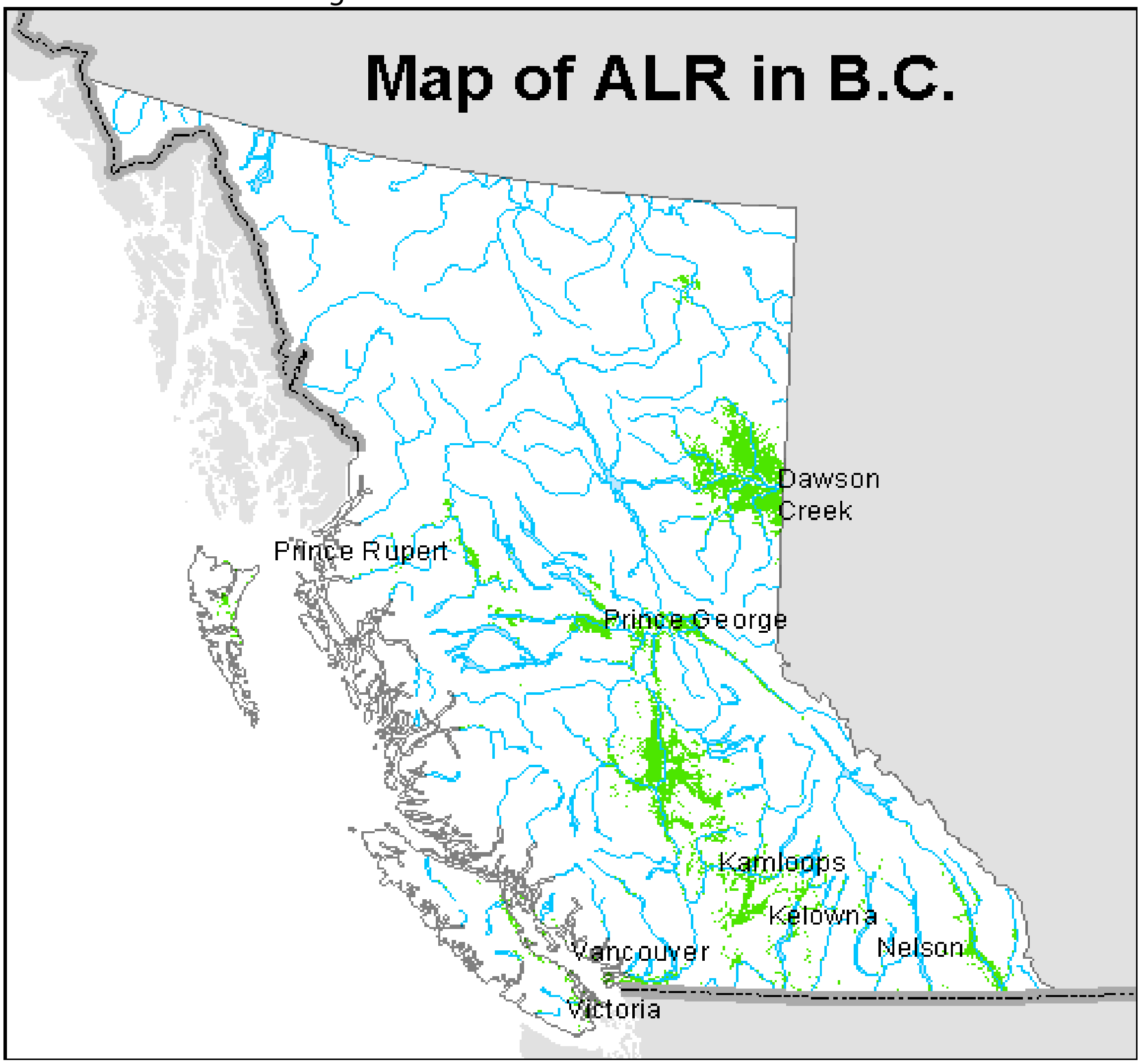
Method	**Environmental Application**
Economic damages from the loss of natural capital or costs avoided by preserving natural capital	
Changes in productivity	Health effects of pollution, loss of natural capital inputs into production, pollution impact on industries
Health-care costs	Health effects of air and water pollution
Loss of capital	What people have to pay for the substitutes for natural capital goods and services; e.g., for sewage and water treatment, noise abatement, greenhouse gas absorption
Willingness-to-pay approaches	
Preventive/mitigating expenditures	Personal or community expenditures to offset noise, visual, air, water-pollution effects
Hedonic estimation of property values	Valuing the impact on property values of proximity to natural capital (forests, water, wetlands). Negative impacts from higher levels of air pollution, noise, toxic wastes due to loss of natural capital
Travel cost	Recreational benefits of improved environmental quality as measured by expenditures to travel to nature sites
Contingent valuation	Asking people their willingness to pay for environmental quality – current and future, or willingness to accept compensation to avoid loss of natural capital goods and services

source: Olewiler, 2004

Appendix B

Map of Agricultural Land Reserve in B.C.

Note: ALRs are shown in green.

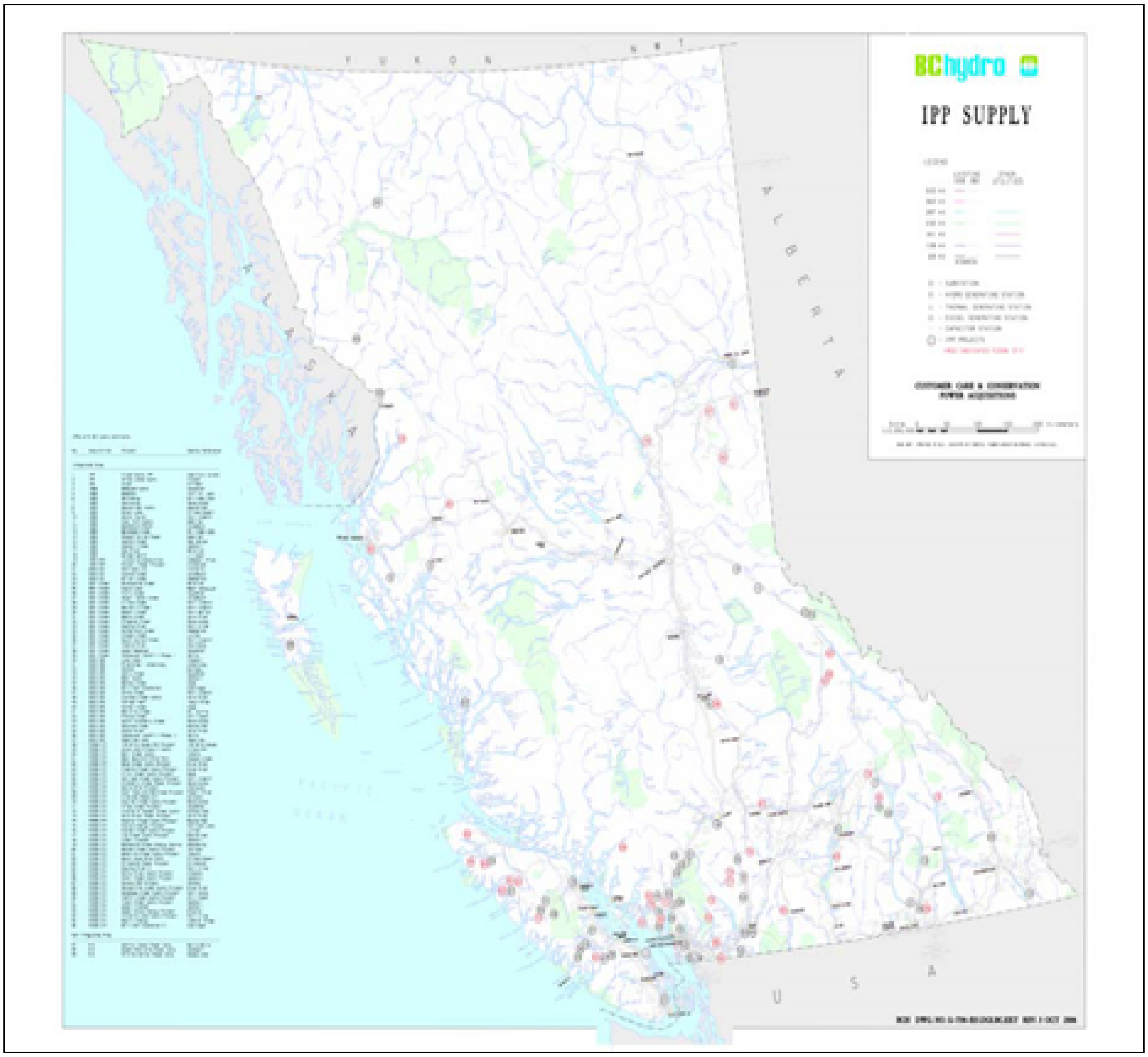


Source: Agricultural Land Commission. ALR Mapping.
http://www.alc.gov.bc.ca/mapping/mapping.htm

Appendix C

Map of Independent Power Production in B.C.

Note: Black and red circles indicate IPPs



Source: BC Hydro IPP Supply Map. www.bchydro.com/etc/medialib/internet/documents/…/illustration_of_bc_by_region_september_2007.Par.0001.File.info50503.pdf

Appendix D

Community	Population 2001 Census	Population 2006 Census	Income 2005	After-Tax Income 2005	Total Labour Force	Occupation	Industry
Port Alice	1,226	821	$22,699	$20,567	450	450	445
Campbell River	35,036	36,461	$24,022	$22,054	19,170	18,745	18,740
Malcolm Island	-	-	-	-	-	-	-
Holberg	169	150	-	-	105	105	105
Quatsino	829	736	$30,064	$27,440	485	480	480
Sayward	379	341	$16,715	$16,715	140	140	140
Klemtu	295	282	$10,144	$10,096	95	95	95
Port Edward	659	577	$23,429	$21,793	280	275	275
Prince Rupert	15,302	13,392	$24,742	$22,797	7230	7025	7025
Kitkatla	50	37	-	-	-	-	-
Blind Channel	2,548	2,472	$21,538	$19,474	1,430	1,410	1,410
Digby Island	91	52	-	-	35	35	35
Gitwinksihlkw	212	201	-	-	115	105	110
Bella Coola	516	421	$26,712	$23,507	215	210	210
Ocean Falls	143	138	-	-	90	95	90
Kemano Beach	-	-	-	-	-	-	-
Skidegate/ Alliford Bay	743	781	$17,216	$17,080	365	355	360
Sandspit	460	402	$26,771	$25,306	260	260	260
Port Clements	516	440	$24,889	$23,978	255	250	250
Port Hardy	4,574	3,822	$25,221	$23,028	2,245	2,205	2,205
Port McNeill	2,821	2,623	$32,857	$28,710	1,665	1,660	1,660
Alert Bay	583	556	$25,594	$23,776	340	335	340
Telegraph Cove	401	304	$24,684	$24,569	185	185	185
Winter Harbour	169	150	-	-	105	105	105
Dawson's Landing	-	-	-	-	-	-	-
Hartley Bay	162	157	-	-	55	55	55
Port Simpson /	667	679	-	-	-	-	-

Georgetown Mills							
Kincolith	339	341	$9,241	$9,241	150	115	115
Oona River/Hunts Inlet	50	37	-	-	-	-	-
New Aiyansh	716	806	$13,620	$13,620	400	385	385
Bella Bella	1,253	1,066	$12,624	$12,624	405	395	395
Kildala Arm	10	5	-	-	-	-	-
Thurston Harbour	460	402	$26,771	$25,306	260	260	260
Queen Charlotte City	1,045	948	$27,122	$25,053	605	605	605
Masset	926	940	$23,502	$22,983	540	535	535
Pncima Total	73,350	70,540	$492,182	$461,722	37,675	36,875	36,875
Provincial Total	3,907,738	4,113,487	$24,867	$22,785	2,226,380	2,193,115	2,193,115
Pncima % of Province	0.0187 or 2%	0.017 or 2%	$	$	0.0169 or 2%	0.0168 or 2%	0.0168 or 2%

Appendix E

Community	Median Income 2005	Total Labour Force	Occupation	Industry	Total Occupation Income	Total Industry Income
Port Alice	$22,699	450	450	445	$10,214,550	$10,101,055
Campbell River	$24,022	19,170	18,745	18,740	$450,292,390	$450,172,280
Malcolm Island	-	-	-	-	-	-
Holberg	-	105	105	105	-	-
Quatsino	$30,064	485	480	480	$14,430,720	$14,430,720
Sayward	$16,715	140	140	140	$2,340,100	$2,340,100
Klemtu	$10,144	95	95	95	$963,680	$963,680
Port Edward	$23,429	280	275	275	$6,442,975	$6,442,975
Prince Rupert	$24,742	7230	7025	7025	$173,812,550	$$173,812,550
Kitkatla	-	-	-	-	-	-
Blind Channel	$21,538	1,430	1,410	1,410	$30,368,580	$30,368,580
Digby Island	-	35	35	35	-	-
Gitwinksihlkw	-	115	105	110	-	-
Bella Coola	$26,712	215	210	210	$5,609,520	$5,609,520
Ocean Falls	-	90	95	90	-	-
Kemano Beach	-	-	-	-	-	-
Skidegate/Alliford Bay	$17,216	365	355	360	$6,111,680	$6,197,760
Sandspit	$26,771	260	260	260	$6,960,460	$6,960,460
Port Clements	$24,889	255	250	250	$6,222,250	$6,222,250
Port Hardy	$25,221	2,245	2,205	2,205	$55,612,305	$55,612,305
Port McNeill	$32,857	1,665	1,660	1,660	$54,542,620	$54,542,620
Alert Bay	$25,594	340	335	340	$8,573,990	$8,701,960
Telegraph Cove	$24,684	185	185	185	$4,566,540	$4,566,540
Winter Harbour	-	105	105	105	-	-
Dawson's Landing	-	-	-	-	-	-
Hartley Bay	-	55	55	55	-	-
Port Simpson (Lax Kw'alaams)/ Georgetown Mills	-	-	-	-	-	-
Kincolith	$9,241	150	115	115	$1,062,715	$1,062,715
Oona River/Hunts Inlet	-	-	-	-	-	-
New Aiyansh	$13,620	400	385	385	$5,243,700	$5,243,700
Bella Bella	$12,624	405	395	395	$4,986,480	$4,986,480
Kildala Arm	-	-	-	-	-	-
Thurston Harbour	$26,771	260	260	260	$6,960,460	$6,960,460
Queen Charlotte City	$27,122	605	605	605	$16,408,810	$16,408,810
Masset	$23,502	540	535	535	$12,573,570	$12,573,570
Pncima Total	$492,182	37,675	36,875	36,875	$884,300,645	$710,468,540

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